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Aeronautical Engineering REVIEW

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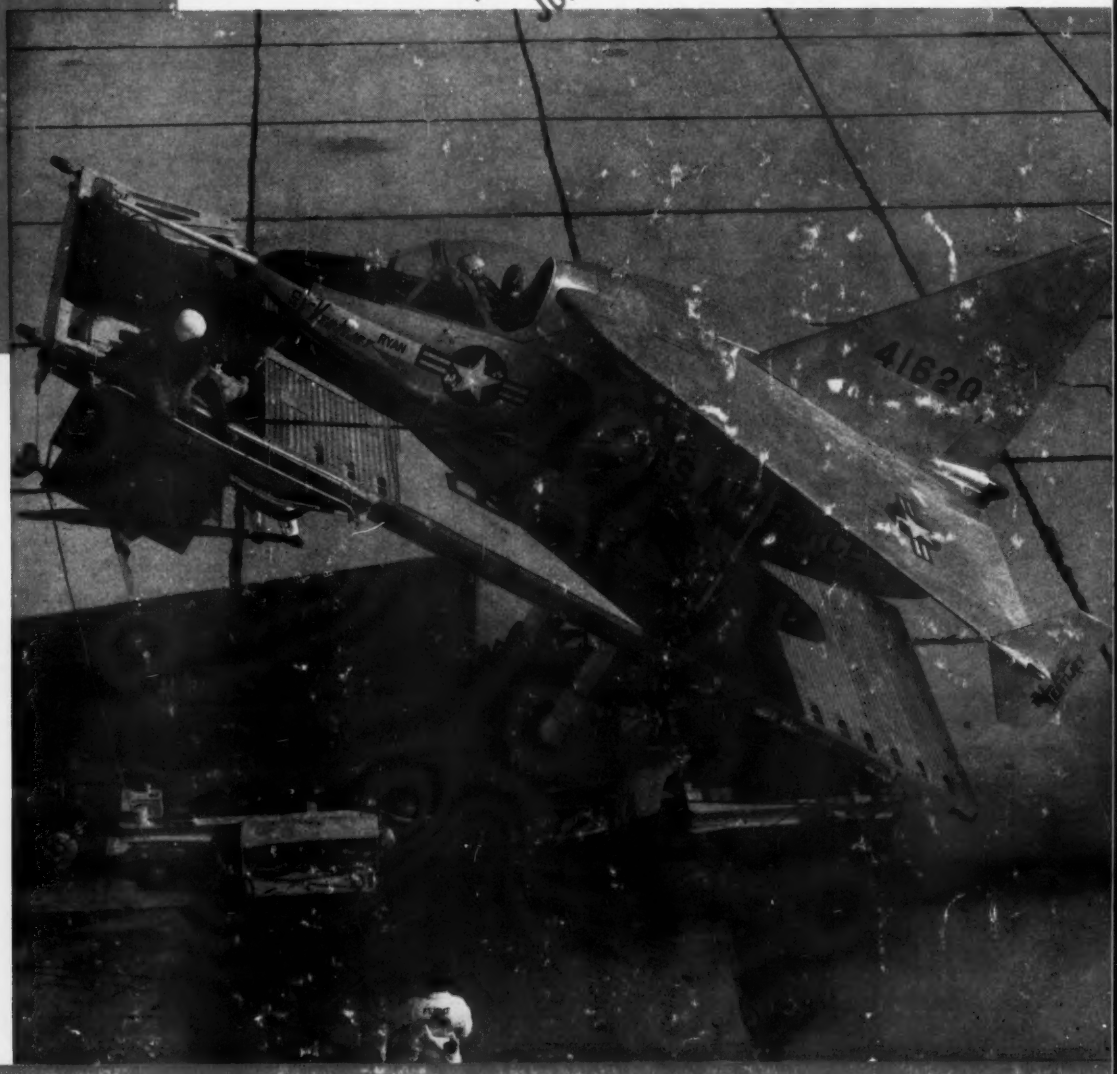


July, 1957

★ ***AIRCRAFT PUMPS***

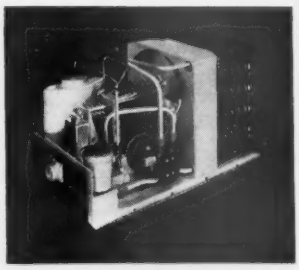
Precision-built to rigid government specifications, a broad selection among Eastern pumps offers flexibility to your choice. Modifications can be made, or custom-made units designed to suit your project. Trim in size, light in weight, Eastern Aircraft Pumps give reliable long-term service.

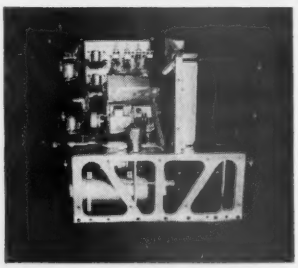
★ ***PRESSURIZATION***

Eastern pressurization units for airborne electronic equipment are available in many capacities to handle a broad range of requirements. Units consist of an air pump and motor assembly, pressure switch, check valve, tank valve, and terminal connectors. They meet government specifications and can be modified to your needs.

eliminate the "BUGS"

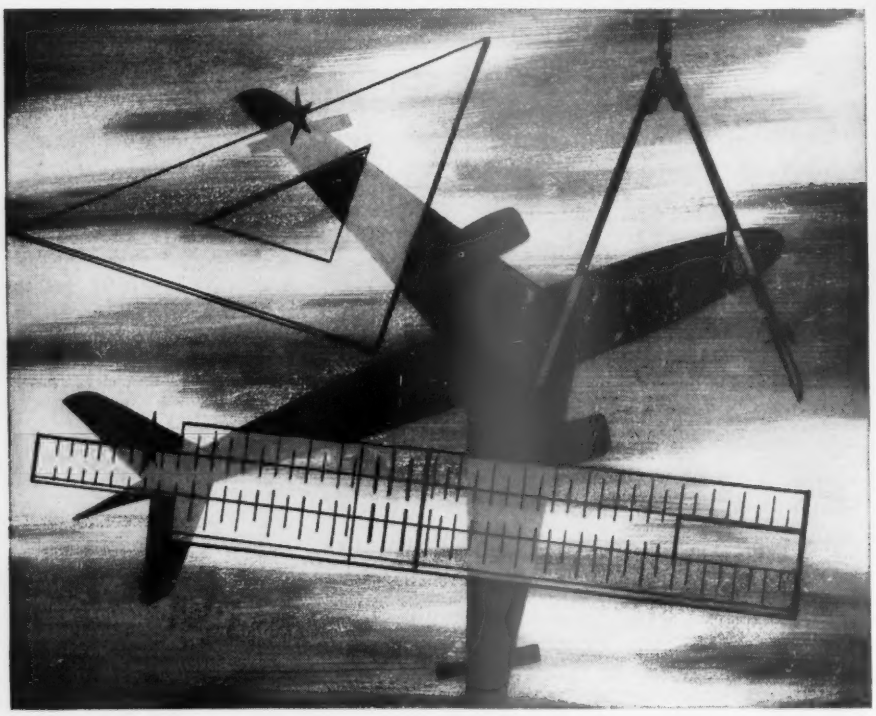
with Eastern aviation products





★ ***COOLING UNITS***

Hold temperatures to safe operating limits in liquid cooled electronic tubes or similiar devices. By virtue of long experience and using standard component parts, Eastern can suit your specific needs at a minimum cost for equipment.



★ ***REFRIGERATION-TYPE***

Enable specified components to be held to fairly constant temperatures by use of various types of refrigeration units. Because of the variation in methods possible, Eastern units fill every requirement where the use of a refrigeration cycle is called for.

★ *SPECIAL UNITS*

Eastern's continual research and development program keeps pace with the growing aviation industry. As new problems occur with progress in aircraft development, Eastern units are constantly developed to fill their function as planes fly higher, or faster, or with greater load capacity.

Eastern welcomes the chance to help engineers "take out the bugs" with equipment that cools, pressurizes, or pumps. From the extensive line of existing units, new adaptations, or custom-made designs, Eastern is ready to meet every challenge for equipment that handles your needs *the best today . . . better tomorrow.*

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Aeronautical Engineering REVIEW

Vol. 16—No. 7 July, 1957

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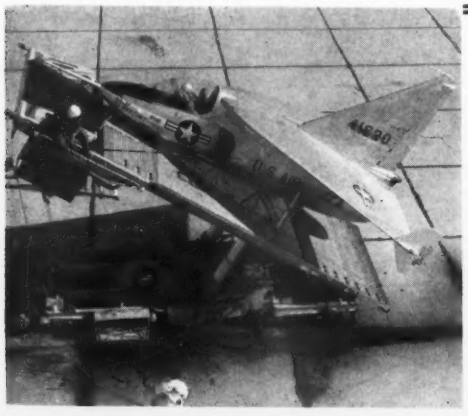

Cover—Ryan Aeronautical Company's X-13 Vertijet is shown in this exclusive photo "bedded" on its specially designed, hydraulic-lift ground service trailer, which places the plane in its vertical take-off position. A Rolls-Royce Avon turbojet (10,000 lbs. thrust) powers the world's first jet VTOL that has two control systems. Ryan-developed jet reaction control determines hovering and near-zero flight, while an aerodynamic control system governs conventional flight. In the reaction system, control forces are developed by engine exhaust deflection and thrust (throttle) variations. First full operational sequence flight in the joint Air Force-Ryan project was made April 11 by Peter F. Girard, Ryan's Chief Engineering Test Pilot.

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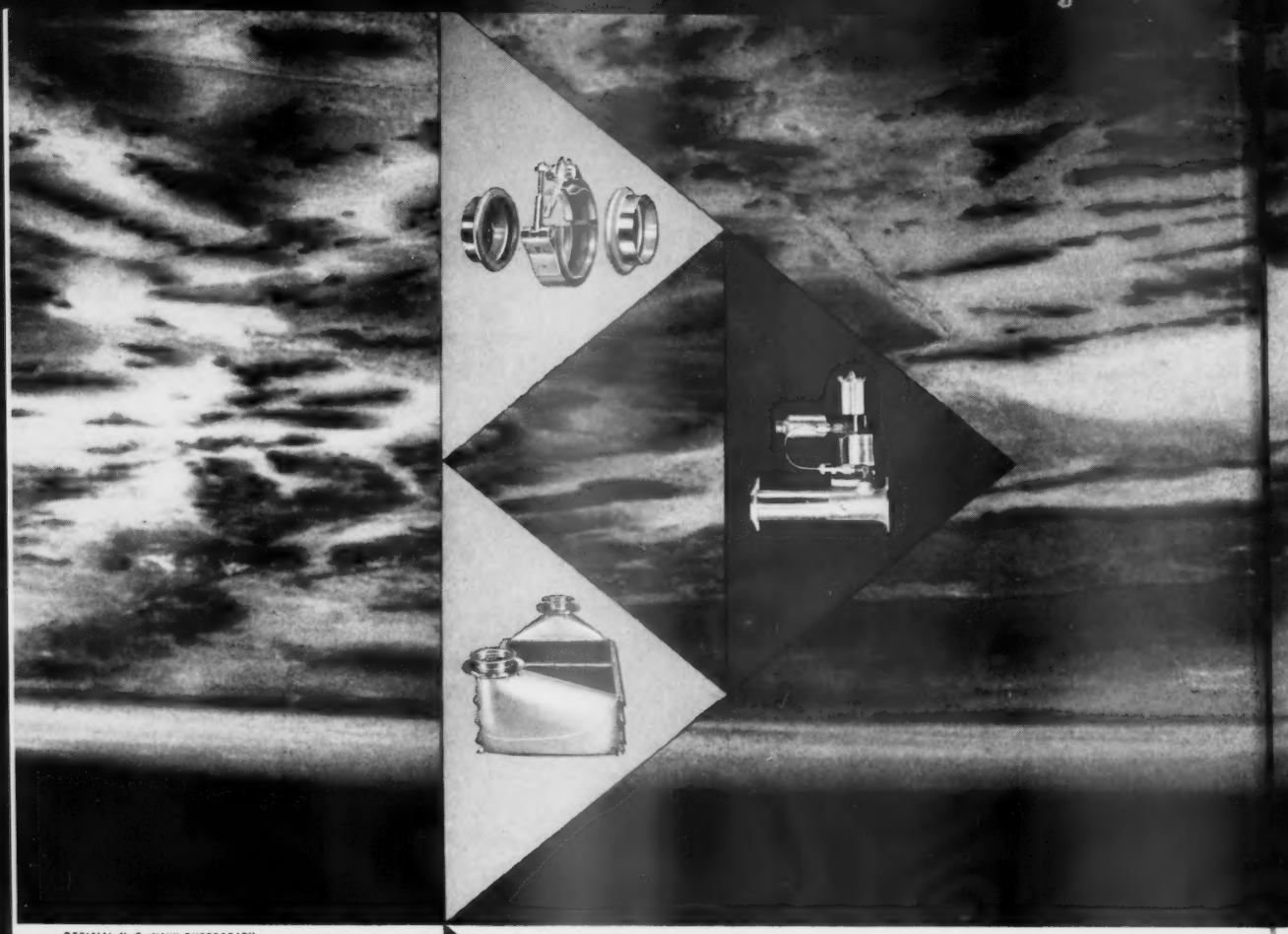

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Beware of the Snark!

The nation's first intercontinental missile . . . the Air Force's Northrop Snark SM-62. Equipped with a nuclear warhead, the Snark is a so-called air-breathing missile which travels in the earth's atmosphere. Its compact design presents a smaller target for radar, interceptors, or anti-aircraft missiles.

Extremely mobile, the Snark can be air lifted to any site within a few hours.

The pilotless bomber is powered by a Pratt-Whitney Aircraft J-57 turbo-jet engine equipped with a Holley compressor bleed governor. It flies in near-sonic speeds above the weather over the longest range yet possible by a missile in the free world today.

Like all Holley engine controls, the compressor bleed governor is dependable, easy to service, compact and lightweight – four vital qualities for aviation equipment.

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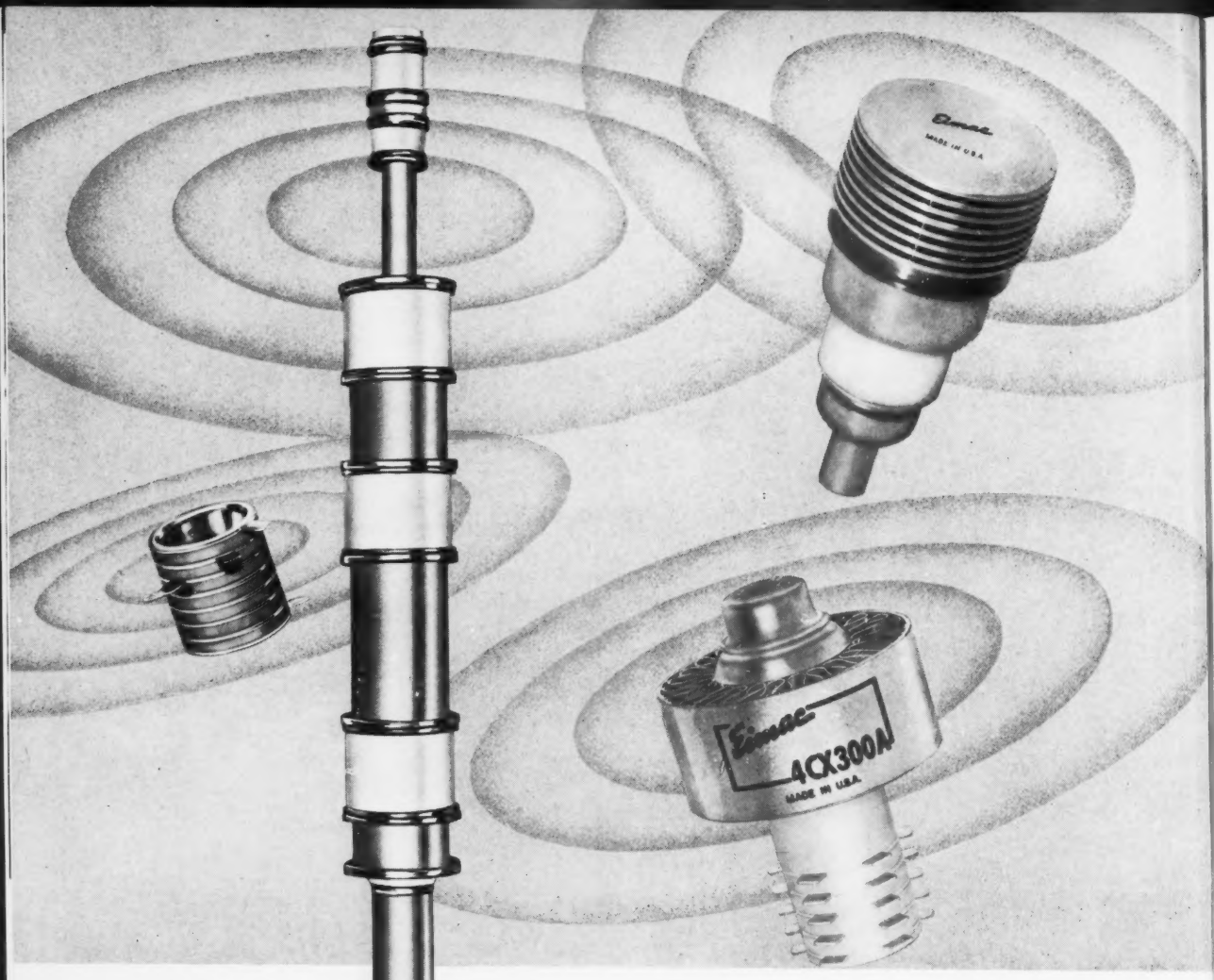
LEADER IN THE DESIGN, DEVELOPMENT, AND MANUFACTURE OF AVIATION FUEL METERING DEVICES.

11955 E. NINE MILE ROAD, VAN DYKE, MICHIGAN



for sound in flight...

Eimac First with ceramic tubes that can take it

Avionic engineers fight a constant battle against several major problems in the design of electronic equipment. Main tube obstacles are: power with small size, and the ability to withstand thermal and physical shock. These obstacles were overcome at Eimac by ceramic construction. Where glass envelope tubes were extremely sensitive to shock, it became evident immediately that the ceramic envelope tube "could take it." It was discovered that ceramic envelope tubes did not suffer from shape distortion under extreme temperatures.

Because ceramic is highly heat resistant, the new Eimac tubes could withstand much higher temperatures than their glass predecessors. Also, the envelope could be reduced considerably in size. As a result, today's 300 watt ceramic tube is only about one eighth the size of its glass envelope counterpart.

Eimac offers a complete family of ceramic tubes "that can take it." Klystrons for ground station use . . . radial beam tetrodes . . . an important new triode . . . plus the new stacked ceramic receiving tubes.

For further information on Eimac tubes that can take it, consult our Application Engineering Department.

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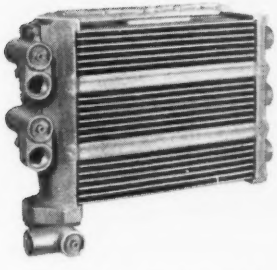
4CX300A
Versatile ceramic tetrode with 300 watts dissipation and extreme resistance to shock

3CX100A5
Premium quality planar UHF ceramic body triode

Oil's cool on the Vertol H-21 Transport Helicopter with HARRISON on the job!

Fahrenheit's right every flight . . . with Harrison on board! Harrison oil coolers keep vital temperatures in check on transmissions and engines . . . allowing 'copters to fly faster, farther and carry heavier payloads than ever before. These oil coolers are compact, save weight and space. They're specially designed to do the job and do it better. You'll find Harrison handling the heat in every line of industry and defense . . . from hydraulic presses to supersonic jets. That's because every Harrison product is backed by over 46 years' experience in producing top-quality heat-control equipment. If you have a cooling problem, look to Harrison for the answer.



Harrison oil coolers level heat for all kinds of aircraft—from small private planes to intercontinental bombers.

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TEMPERATURES MADE TO ORDER

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RADIATOR DIVISION, GENERAL MOTORS CORP., LOCKPORT, N.Y.

Solar Advanced Technology

Taming hard-to-work titanium with "purge chamber" welding

AIRCRAFT AND MISSILE DESIGNERS call for more and more titanium. The superior strength-to-weight ratio of this new metal saves vital pounds in airframe, engine and missile components. Solar is leading the way in taming this hard-to-work metal.

The plastic purge chamber, shown above, is a Solar development to facilitate welding of titanium in an atmosphere which protects the weld from elements in the air. It is one of many advanced fabricating techniques perfected in Solar laboratories to help realize titanium's promise. As a result, Solar today is among the largest users of titanium for aviation purposes, and is constantly testing and working with new materials requiring experience and expert ability.

This is one example of Solar advanced technology—a combination of skills, facilities and forward-looking pioneering. Perhaps Solar can bring a fresh viewpoint to your difficult metal-working problems. Write to Department D-39, Solar Aircraft Company, San Diego 12, California.

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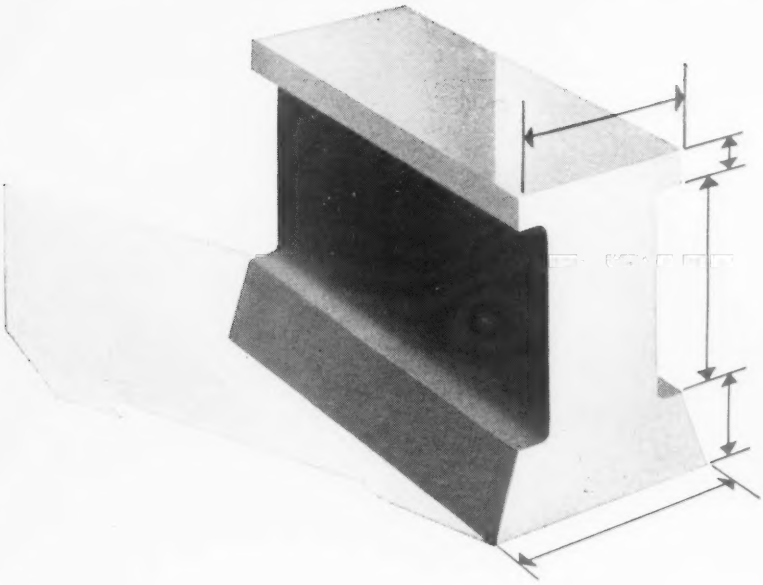
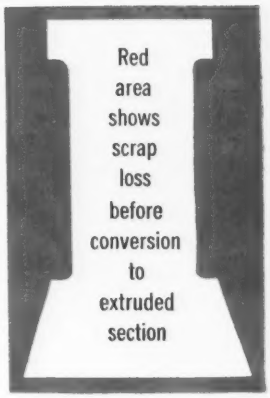
Cost per clamp cut from $1.06 to 58¢ with J&L hot extruded cold drawn section





This manufacturer cut the cost of contact clamps 45% by converting to J&L extruded sections. Previous cost of $1.06 per part involved costly milling and scrap loss from cold drawn 1½" x 1" flats.

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1. Eliminate machining and finishing operations.
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Vibration, shock and climate extremes have no adverse effect on the Fenwal units.

The line embodies heater controls, cooling effect detectors, differential thermostats, baggage compartment over-heat detectors and midget and miniature controls for tight-spot installations.

All are extremely light and compact.

For details on any or all, write to **Fenwal Incorporated, Aviation Products Division, 175 Pleasant St., Ashland, Massachusetts.**

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CONTROLS TEMPERATURE ...PRECISELY

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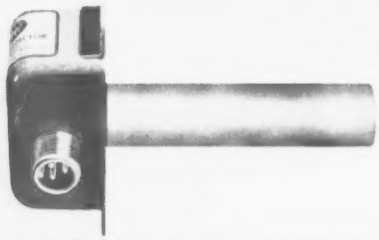
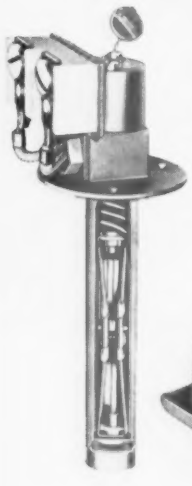


COOLING EFFECT DETECTORS — Functions in same manner as equipment it protects, to sense effect of cooling air.



HEATER CONTROLS, BAGGAGE COMPARTMENT FIRE DETECTORS, DIFFERENTIAL THERMOSTATS — Each uses the THERMOSWITCH unit principle, meaning that each fulfills its special function aboard aircraft with unmatched accuracy and quickness of response. All such units, regardless of function, are light, compact, and hermetically-sealed in stainless steel.

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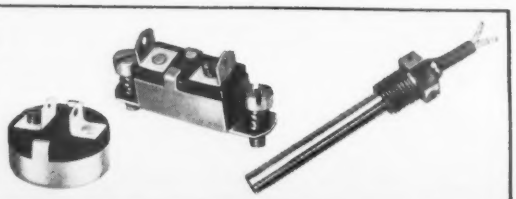

Shafer Aircraft Bearings are used on both the 400,000-lb. Boeing B-52 global heavy bomber and the tiny 3-ton Cessna T-37 trainer—the Air Force's largest and smallest jet aircraft!

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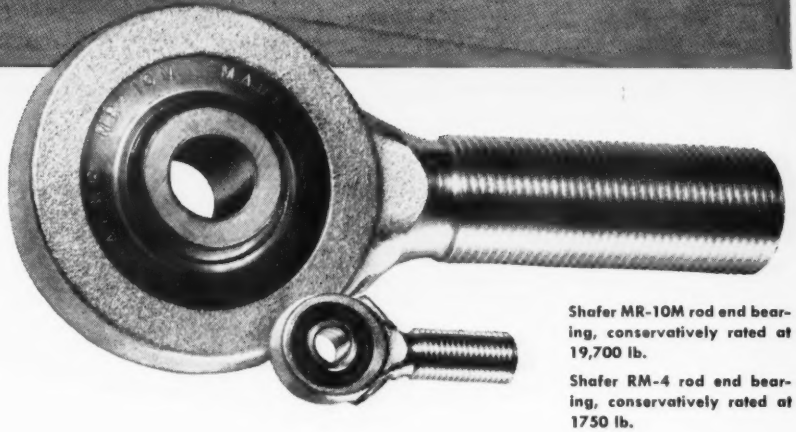

Shafer MR-10M rod end bearing, conservatively rated at 19,700 lb.

Shafer RM-4 rod end bearing, conservatively rated at 1750 lb.

SHAFER BEARINGS HAVE GREATEST CAPACITY FOR THE SIZE

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Weight 102 lb

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Model AC26-39
Capacity at
30,000 ft.
50 lb/min
Weight 55 lb

Evolution in cabin air compressors

New AiResearch unit weighs one-third as much, increases performance by 43%

The performance demands on aircraft cabin air compressors are constantly increasing. Yet weight and space limitation on these pressurization components becomes even more critical. Basic design advancement is the only solution.

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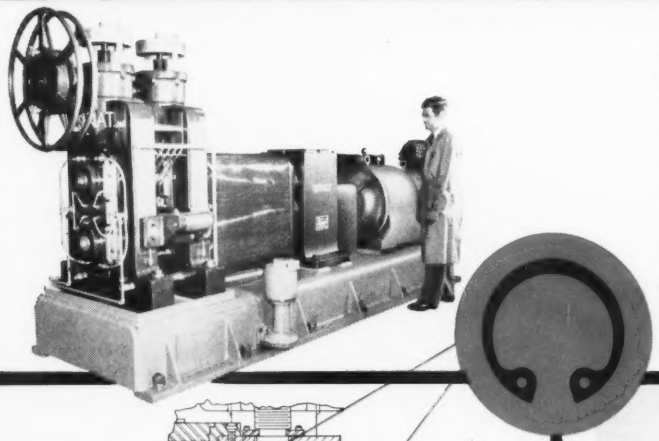
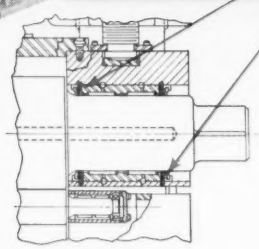
7-inch Waldes Truarc retaining rings cut costs, speed assembly-disassembly of 2-high/4-high mill

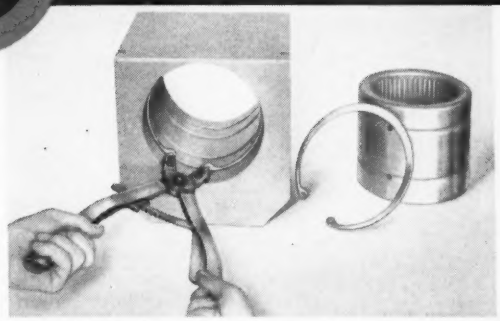


New Model TA-625 2-high/4-high combination rolling mill designed by Stanat Manufacturing Co., Long Island City, N. Y., reduces 2½" ingot to precision-rolled strip as thin as .001".

Waldes Truarc retaining rings help make possible a complete change of work rolls in 20 minutes...solve difficult problems of accuracy control by achieving positive location of bearings to extremely close tolerances. Rings eliminate costly parts and machining, save space, reduce maintenance.



In the assembly illustrated above, 7" Waldes Truarc (Series 5000) retaining rings—three on each roller—are used to position heavy-duty needle bearings in the bearing housing. Smaller rings position bearings in other roller assemblies and retain the shaft of a dual handwheel screwdown. All in all, 18 Waldes Truarc rings are used in the mill. They replace machined shoulders, spacers and lock nuts...eliminate costly threading, other machining operations.



Assembly is simple, even with giant 7" diameter Truarc ring. Special Truarc ratchet pliers grasp the ring securely, ease it into the groove, snap it securely into position. Smaller pliers and various high-speed assembly jigs are available for other rings, permit assembly-disassembly to be performed rapidly even by unskilled labor.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product...to save you material, machining and labor costs. Quick and easy to assemble and disassemble, they do a better job of holding parts together. Truarc rings are precision-engineered and precision-made, quality controlled from raw material to finished ring.

36 functionally different types...as many as 97 different sizes within a type...5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U.S.A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today...let our Truarc engineers help you solve design, assembly and production problems...without obligation.

For precision internal grooving and undercutting...Waldes Truarc Grooving Tool!

WALDES TRUARC® RETAINING RINGS

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WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

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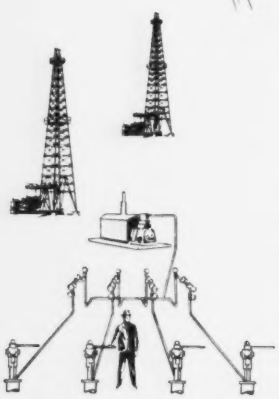

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IAS News Notes

July 1958

THE INSTITUTE will act as permanent secretariat of the new INTERNATIONAL COUNCIL OF THE AERONAUTICAL SCIENCES, the first world-wide organization formed specifically to extend collaboration in all scientific areas pertaining to mechanical flight. The first International Congress of the organization will be held in Madrid, Spain, in September, 1958. Full details will appear in the August issue of the Review.

AN AIR FORCE ROCKET PLANE PILOT, Lieutenant Colonel Frank K. Everest, Jr., has been named winner of the Institute's 1957 Octave Chanute Award "for his outstanding contributions to the development of rocket-powered flight test techniques." He was the first pilot to fly the Bell X-2 research aircraft.

JEROME C. HUNSAKER (HF) will receive the Royal Aeronautical Society's highest honor at its Wilbur Wright Lecture, September 13. He will be awarded the Society's Gold Medal "for his contributions to aeronautical research and education, including his inspired chairmanship of NACA." He delivered the 1920 Wright Lecture.

A KANSAS CITY SECTION, the 28th section in the IAS, has been formed by members in that area. A Steering Committee headed by R. P. Kroon (M) carried out organization procedure. More about this in the August issue.

CAPTAIN IVEN C. KINCHELOE, JR. (A), Experimental Flight Test Officer at Edwards Air Force Base, has been awarded the Air Force Mackay Trophy for 1956. Capt. Kincheloe "... distinguished himself by extraordinary achievement during aerial flight in the X-2 rocket-powered research aircraft."

REQUESTS FOR INFORMATION on the Weapons System Management Meeting, sponsored by the Texas Section, will receive prompt attention and result in quicker replies if addressed to the Meeting Secretary, Harold F. Johnson, 1004 University Drive, Apt. 131, Fort Worth 7, Texas.

LATEST CORPORATE MEMBERS of the Institute are The Ramo-Wooldridge Corporation, 5730 Arbor Vitae Street, Los Angeles 45, California, and International Business Machines Corporation Military Products Division, 590 Madison Avenue, New York 22, New York.

A GROUP OF IAS MEMBERS, headed by Willi F. Jacobs (M), President, have formed the Research Engineering Services Corporation, whose announced goal is to make available to general industrial groups the technological advances in aeronautics. Five of the firm's 12 founders are Institute members.

NATIONAL NAVAL AVIATION MEETING luncheon speakers will be Captain Donald B. MacDiarmid, USCG, Operations Officer, 14th Coast Guard District, Hawaii, on Tuesday, August 6, and J. H. Kindelberger, Board Chairman, North American Aviation, Inc., on Thursday, August 8. Luncheon forms and meeting programs are in the mail to all IAS members.

NEWS OF THE DEATH of Emerson C. Briggs (M) on May 8, has been received at IAS National Headquarters. A Stress Analyst for Kaman Aircraft Corporation, Mr. Briggs was forty-three.

CLARK B. MILLIKAN (HF), Director, Guggenheim Aeronautical Laboratory and Southern California Cooperative Wind Tunnel, will give the Royal Aeronautical Society's annual Wilbur Wright Lecture, on September 13 in Great Britain.

NATIONAL MEETINGS CALENDAR

Aug. 5-10	National Naval Aviation Meeting, U. S. Grant Hotel, San Diego, California.
Sept. 1-15	Sixth Anglo-American Aeronautical Conference, Royal Aeronautical Society and IAS, London and Folkestone, Great Britain.
Oct. 21-22	Canadian Aeronautical Institute-IAS Meeting, Montreal, Canada.
Nov. 7-8	Weapons System Management Meeting, Statler-Hilton Hotel, Dallas, Texas.
Dec. 17	Wright Brothers Lecture, Washington, D. C.
1958	
Jan. 27-31	Twenty-Sixth Annual Meeting, Sheraton-Astor Hotel, New York.
September	First International Congress, International Council of the Aeronautical Sciences, Madrid, Spain.

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SECTION MEETINGS CALENDAR

July 9	Los Angeles Section: Specialist Meeting, IAS Building, 8 p.m. "Generation of Surface Waves by Shear Waves" by J. W. Miles.
July 10	Texas Section: Specialist Meeting, Engineering Auditorium, Arlington State College, 8 p.m. "Future Trends in Aircraft Engines" by Elmer Paulson.
July 11	San Diego Section: Field Trip - Convair Plant No. 2, 4297 Pacific Highway. "F-102 Production Line."
July 23	San Diego Section: Dinner Meeting, IAS Building, 6:30 p.m. "Engineering Management Relations" by R. C. Sebold.

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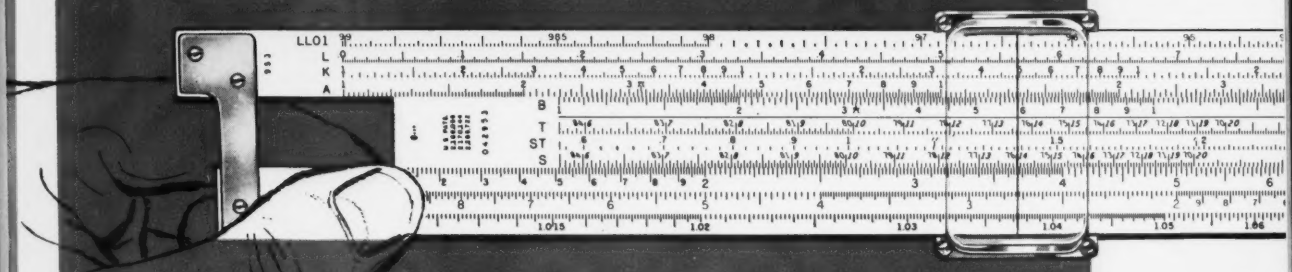
LOOKING FOR ENGINEERS?



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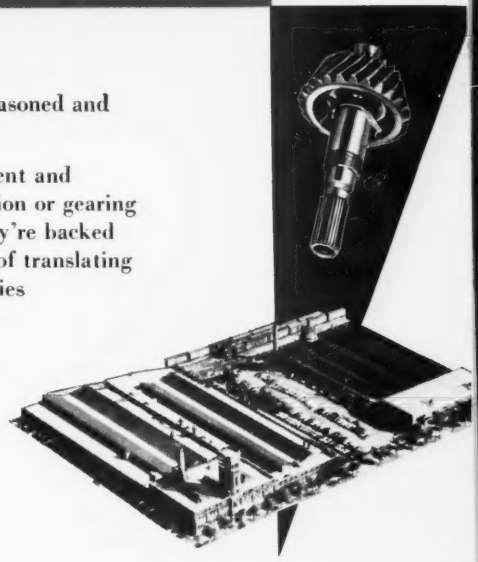

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IAS News

A Record of People and Events of Interest to Institute Members

National Naval Aviation Meeting

4 Days of Technical Sessions, Carrier Cruise Planned

33 Papers to Be Presented at First Meeting, Aug. 5–10

THE INSTITUTE'S first National Naval Aviation Meeting in San Diego, Calif. August 5–10, will feature 4 days of technical sessions and a day's cruise (August 7) aboard the carrier U.S.S. "Ticonderoga."

A total of 33 classified and unclassified technical papers will be read—classified papers at Marine Corps Recruitment Depot Auditorium and the remainder at meeting headquarters, the U.S. Grant Hotel.

An air show at the Navy's Miramar Air Station is scheduled for August 10, and a display of naval historical material will be set up at the IAS building.

Secretary of the Navy Thomas S. Gates, Jr., will be guest speaker at a banquet the evening of August 5. Rear Admiral J. S. Russell, Chief, BuAer, is Honorary Chairman.

The Institute's Water-Based Aviation Award, first presented to pioneers in the field at the last Annual Meeting, will be given to an outstanding contemporary to be named at this meeting.

Sessions, chairmen, papers, and speakers scheduled are as follows:

Monday, August 5, 8:45 a.m. (Classified): Chairman—Rear Adm. R. E. Dixon. "Navy Roles and Missions," Vice-Adm. W. V. Davis, Jr., Deputy Chief, Naval Operations Air; "New Concepts of Naval Air Weapons Systems," Capt. T. F. Caldwell, Head, Air Weapons Systems Analysis Staff, CNO; "Concepts of Future Aviation Employment by the U.S. Marine Corps," Lt. Gen. V. J. McCaul, Director, Marine Aviation; "Navy Guided Missiles Programs," Rear Adm. J. E. Clark, Director, Guided Missiles Division, CNO.

1:30 p.m. (Classified): "Long-Range Planning in BuAer," Rear Adm. W. A. Schoech, Assistant Chief, Research and Development, BuAer; "Research and Development Programs," Rear Adm. Selden B. Spangler, Commander, Naval Air Development and Materiel Center, Johnsville; "Office of Naval Research Objectives and Programs in Aeronautics," Capt. A. B. Metsger, Deputy and Assistant Chief, Office of Naval Research; "Air Weapons Development in the Bureau of Ordnance," Capt. R. M. Pray, Program Director, Air and Atomic Ordnance, Bureau of Ordnance.

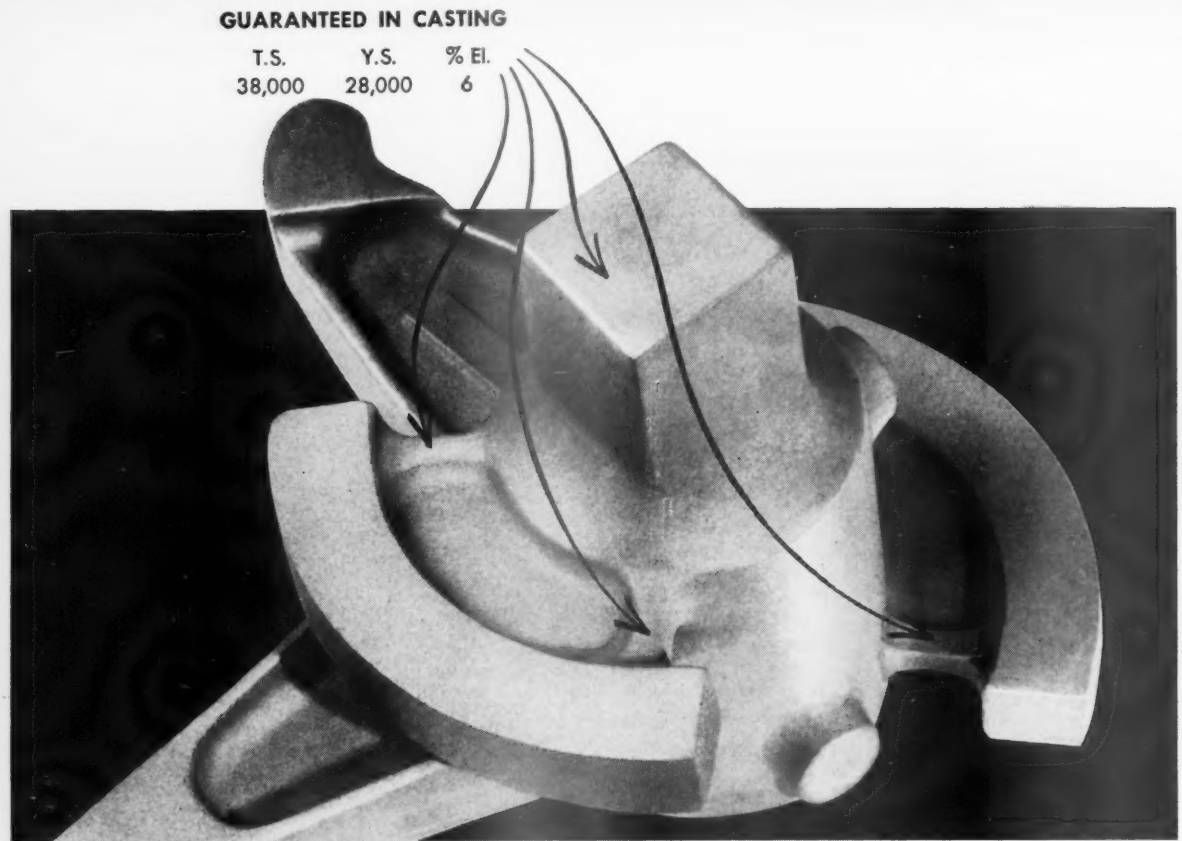
Tuesday, August 6, 8:45 a.m., *Water-Based Aircraft:* Chairmen—Rear Admiral Spangler and J. B. Parkinson, Chief, Hydrodynamics Division, NACA Langley Aeronautical Laboratory. "Development of the Seamaster," W. F. Hess, The Martin Company; "The Hydrofoil: Its Development and Application to Water-Based Aircraft," W. P. Carl and H. B. Suydan, Grumman Aircraft Engineering Corporation; "New Method for Predicting the Hydrodynamic Characteristics of Water-Based Aircraft," R. H. Oversmith, Convair, A Division of General Dynamics Corporation; "Nuclear Power Plants for Air-Borne Vehicles," Ralph Zirkind, BuAer.

1:30 p.m., *STOL, VTOL, and Helicopters:* Chairmen—Capt. S. S. Sherby, Office of Naval Research, and Charles H. Zimmerman, Assistant Chief, Stability Research Division, NACA Langley. "The Systems Approach to the Selection of VTOL Aircraft Design Specifications," F. D. Schnebly, Hiller Helicopter Co.; "Development of a Vertical Take-Off Jet-Propelled Aircraft," H. L. Braasch and R. A. Fuhrman, Ryan Aeronautical Company; "Some Considerations in the Design and Testing of Horizontal Attitude VTOL Jet Airplanes," C. D. Ray and J. A. O'Malley, Bell Aircraft Corporation; "Helicopter Towing Capabilities," G. G. Spratt and D. A. Richardson, Vertol Aircraft Corporation.

William H. Mollering
General Chairman

Thursday, August 8, 8:45 a.m., *Carrier-Based and Land-Based Aircraft:* Chairmen—Charles Tilgner, Jr., Chief Engineer, Grumman, and Captain Caldwell. "Analysis of Air Warfare Problems," F. Gloeckler, Naval Air Development Center; "The Human Factor—Most Neglected Element of Design," Capt. J. Sinkankas, Staff, Commander, Fleet Air Pacific; "The Role of Land Planes in Naval Aviation," speaker from Lockheed Aircraft Corporation to be announced; "Operational Problems Posed by Limited Endurance Life of Naval Combat Aircraft," C. P. Baum, BuAer.

1:30 p.m., *Carrier-Based Aircraft and Missiles:* Chairmen—R. C. Sebold, Vice-President—Engineering, Convair, and Rear Adm. J. E. Clark. "Carrier Take-Off and Landing Considerations," J. E. Barth and E. R. Heald, El Segundo Division, Douglas Aircraft Company; "Progress in Naval Use of Aerial Refueling," A. M. McKenzie, BuAer; "The Role of Flight Safety Engineering in Aircraft Reliability and Effectiveness," C. O. Miller, Chance Vought Aircraft, Inc.; "Manufacturing, Research and



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LIGHT METALS DEPARTMENT
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Development for Terrier Missile," E. D. Heller, Convair, Pomona.

Friday, August 9 (Classified): Chairmen—Abraham Hyatt, Research and Analysis Officer, BuAer, and Frank Fink, Vice-President—Engineering. Ryan. "Hydrodynamic Research and Development," E. H. Handler, BuAer; "A Possible New Weapon System for Aircraft Use in Anti-Submarine Warfare," C. A. Gongwer and R. M. Viney, Aerojet-General Corporation; "The Helicopter as an ASW Vehicle," Lt. Comdr. F. N. Masuen, Staff, Commander, Fleet Air, Hawaii; "Evolution of the AEW Airship," F. B. Sandgren, Goodyear Aircraft Corporation.

1:30 p.m. (Classified): Chairmen—Rear Adm. J. B. Pearson, General Representative, Western District, BuAer, and Raymond Blaylock, Vice-President—Engineering, Chance Vought. "Outer Perimeter Fleet Air Defense for the 1963–1968 Period," H. Kaufman, Naval Air Development and Materiel Center; "Balanced Weapons Systems, The Case of the Naval Interceptor," C. M. Forsyth, McDonnell Aircraft Corporation; "Design Problems in Operation of Modern Carrier-Based Aircraft," Capt. T. D. Davies, Naval Air Materiel Center; "Design and Development of the F8U-1 Crusader," M. J. R. Clark, Chance Vought; "Problems in the Initiation of the F4D in the Atlantic Fleet Marine Fighter Squadron," Col. M. E. Carl, Staff, Commanding General, Air, Fleet Marine Forces Pacific.

Other events on the schedule include luncheons at noon on August 6 and 8 and open house at Convair, Rohr, Solar, and Ryan facilities. A national hook-up TV show has been planned.

The carrier cruise, limited to 600 persons, will be highlighted by all carrier operations. A Regulus missile will be fired from a submarine and Terrier missiles from the U.S.S. "Norton Sound."

The Navy's flying acrobatic team, the Blue Angels, will perform at the Miramar air show, and demonstrations of latest Navy aircraft will be seen. The Marine Corps will perform a vertical envelopment maneuver.

British Rocket Symposium Schedules 8 Technical Papers

A tentative program of papers has been announced for the Symposium on High-Altitude and Satellite Rockets, sponsored by the Royal Aeronautical Society, British Interplanetary Society, and College of Aeronautics and scheduled for July 18–20 in Great Britain.

Technical papers will include "Scientific Uses" by H. S. W. Massey, University College, London; "The Gassiot High-Altitude Rocket" by W. H. Stephens, RAE; "Propulsion Problems" by A. D. Baxter, College of Aeronautics; "Design Problems" by K. J. Bossart, Convair-Astronautics, General Dynamics Corporation; "Re-Entry and Recovery" (two papers) by W. F. Hilton, Armstrong-Whitworth, and N. C. Freeman, NPL; "Guidance, Instrumentation, and Telemetry" by A. W. Lines, RAE; and "Future Developments" by L. R. Shepherd, AERE. These will be given on Thursday, July 18, and Friday, July 19.

An informal reception is set for Wednesday evening, July 17. The Symposium Dinner is scheduled for Friday evening, July 19.

Edward P. Warner Retires From ICAO Council Presidency

Edward P. Warner (HF), Council President, International Civil Aviation Organization, has retired from the ICAO, a United Nations specialized agency.

Dr. Warner was elected President of the Council in 1945 and subsequently re-elected three times. He was leader of the Council for 11 years during which time ICAO grew from 26 to 70 cooperating nations.

In addition to heading the ICAO Council, he has been Assistant Secretary of the Navy for Aeronautics, Editor of *Aviation* magazine, a Staff Member of the CAA and CAB, and the first United States Delegate to the ICAO.

New Firm's Senior Staff Is One Third IAS Members

A newly established independent research organization, The Midwest Applied Science Corporation, has four members of the Institute (one is a Director of the firm) on its eleven-member Senior Staff.

All are members of Purdue University's aeronautical engineering faculty. They are Hsu Lo (M), Director; R. J. H. Bollard (M); A. C. Eringen (M); and A. Miele (M).

The firm says its research and consulting staff is assisting several industries with problems in automatic controls, computers, mathematics, aerodynamics, thermodynamics, heat transfer, stress analysis, and structural design.

Southwest Products Co. Joins IAS Corporate Membership

Southwest Products Company, manufacturer of self-aligning ball bearings, has joined the Institute as a Corporate Member. The firm was founded in 1945 by K. V. Hackman, President and General Manager, and is located at 1705 South Mountain Avenue, Monrovia, Calif.

Two kinds of self-aligning bearings produced by Southwest are the plain bearing of two pieces—a spherical ball with a hole for a close-tolerance bolt or shaft to pass through and a one-piece outer race which completely surrounds the ball—and the rod end "Monoball" self-aligning bearing. The Monoball bearing is installed in a housing shaped like an eye bolt and in the end of a rod to engage a bolt fastened to a yoke, crevis, or arm.

Not intended for the antifriction purposes of ball or roller bearings supporting rotating or r.p.m. shafts, Monoball bearings have applications in various sizes in aircraft or similar structures, especially those subject to twists, vibrations, and strains. They are used as support for actuating cylinders, retractable landing gear, landing gear strut, and trunnions.

NEWS OF MEMBERS

▶ **Bernard A. Hohmann** (M) has received the Air Force Meritorious Civilian Service Award, second highest honor granted to civilians. Mr. Hohmann is Chief of the Flight Development Section, Aircraft Laboratory, Wright Air Development Center. The award was made for directing the development of new concepts in aircraft range extension.

Members on the move . . . .

This section provides information concerning the latest affiliations of IAS members. All members are urged to notify the News Editor of changes as soon as they occur.

L. A. Bullard, Jr. (AF), former Midwest District Manager, Greer Hydraulics, Inc., is Sales Manager, Eastern Aircraft Products Corporation, a subsidiary of The Weatherhead Company.

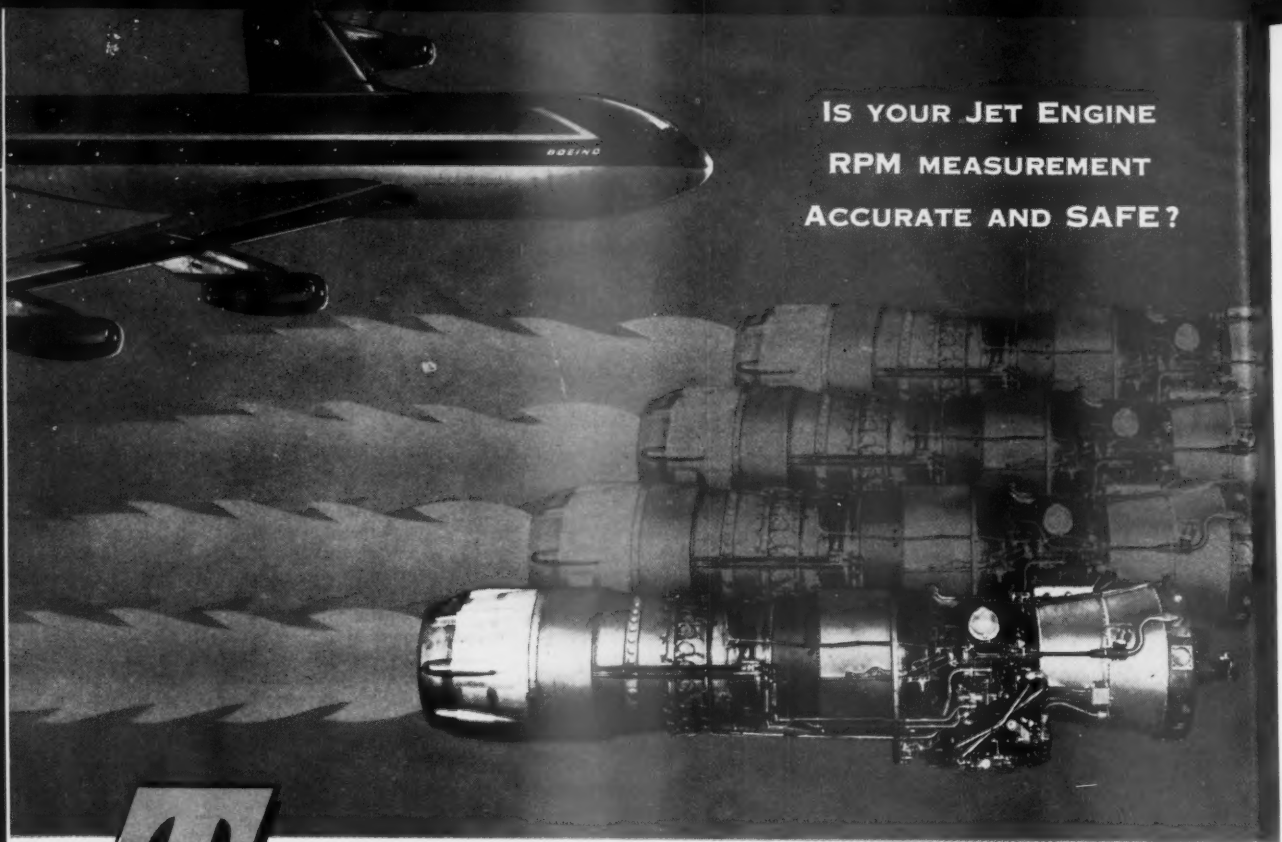
William H. Enders (M), formerly Chief Development Engineer, Aeronca Manufacturing Corporation, Middletown, Ohio, has joined Airborne System Laboratory, Defense Electronics Products, Radio Corporation of America, Waltham, Mass. His position is Senior Project Member, Technical Staff.

Heinz Fornoff (M), former Drone and Missile Flight Control Department Head, Sperry Gyroscope Division of Sperry Rand Corporation, has been named Vice-President for Engineering, Specialties, Inc.

Harry J. Graham (M), former Chief Engineer, Lycoming Division, Avco Manufacturing Corporation, has been appointed Director of Engineering, Clinton Machine Company, Clinton, Mich.

Willis M. Hawkins (M), Assistant General Manager, Missile Systems Division, Lockheed Aircraft Corporation, has been

(*Continued on page 70*)



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The TAKCAL's component parts are identical with those used in the J-Model JETCAL Analyzer. They are here assembled as a separate unit tester and for use with all earlier models of the JETCAL Tester.

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Princeton Host to Six Schools and USAF Chief Scientist at Northeastern Student Conference

Five undergraduate and ten graduate papers were presented at the IAS Northeastern Region Student Conference at Princeton University, March 29 and 30. Seven schools including Princeton participated.

Number one paper in the undergraduate division was "Determination of Pressure Drag on Bodies of Revolution in Transient Flight," given by Samuel J. Harris, III, Virginia Polytechnic Institute.

Graduate first prize went to Herman Mark, Cornell University, whose paper was "The Interaction of a Reflected Shock Wave with the After-Flow Boundary Layer."

The winners were determined by a board of judges headed by R. G. Bowman, Republic Aviation Corporation; M. H. Bloom, Polytechnic Institute of Brooklyn; R. A. Gross, Fairchild Engine and Airplane Corporation; Capt. H. S. Murphy, U.S. Navy Training Service Center; C. E. Pappas, Republic; C. B. Smith, Pratt & Whitney Division, United Aircraft Corporation; and Charles Tilgner, Jr., Grumman Aircraft Engineering Corporation.

Highlight of the conference was the award banquet at which Courtland D. Perkins, Air Force Chief Scientist, spoke on "The Young Engineer Looks Ahead." (Excerpts from his address appear as the guest editorial in this issue.)

Perkins' Speech

Professor Perkins said the young aeronautical engineer's wagon is hitched to the Armed Forces, the planning for which is in the hands of the Department of Defense. He suggested the engineer become familiar with the Department's planning. Although his field may look unstable because of its tie to the military, the facts show a steady growth over past years. The major force behind this growth today and the one which keeps industry operating at top effort is the technological race with the Soviet, he said. Because Soviet economy permits greater research and development and is turning out engineers at twice the rate of the West, our great need is for "quality" engineers to direct programs toward their simplest, most effective solution.

This was the central point of Professor Perkins' talk, after which he went on to discuss major fields of aeronautical development. In this area he dwelt on problems of missile re-entry, higher lift to drag ratios, high Mach stability and control problems, high internal and skin temperatures, and rocket and jet power plants.

Distinguished Guests

Toastmaster at the banquet was Charles Tilgner, Jr., Chief Engineer, Grumman Aircraft Engineering Corporation. Also at the speakers' table were N. R. Augustine, Princeton Student Branch Chairman; J. C. Elgin, Dean, School of Engineering; S. Paul Johnston, IAS Director; D. C. Hazen, Student Branch Faculty Adviser and Professor of Engineering; T. F. Hammen, Jr., Chairman, Student Activities, IAS New York Section; and Mr. Bowman, who headed the board of judges.

A visit to the Forrestal Research Center facilities took place after the papers were delivered. Among displays presented for the 120 conference guests was a demonstration of Princeton's three-dimension smoke tunnel and static test firing of a small, liquid propellant rocket. The formal paper competition was opened Saturday morning at the Center. Jack Snell, Secretary, Princeton Branch, was Undergraduate Session Chairman, while Doug Beatty, Branch Vice-Chairman, presided at the graduate level.

Other Prize Winners

Undergraduate second prize winner was Norman R. Augustine, Princeton, whose paper was "Fluid Wings." Third prize was won by Adolf K. Anderson, Jr., Virginia Poly, for his paper "Aerodynamic Heating on Bodies of Revolution Including Slip Flow."

Second prize on the graduate level was won by A. D. Wood, Brown University, for "Linearized Flow in Cascades." C. F. Chen, also of Brown won third prize with "Mean Boundary Conditions for a Wall with Longitudinal Slots."

JACK SNELL
Secretary
Princeton Student Branch

Left: **An informal get-together was held for the 120 guests and participants at the Northeastern Student Conference at Princeton University on March 29 and 30.** ***Right:*** **Students and guests toured Princeton's Forrestal Research Center facilities where a small, liquid-propellant rocket was fired and the Center's three-dimensional smoke tunnel was demonstrated.** ***Bottom:*** **R. G. Bowman, Republic Aviation Corporation, who headed the judges of the student paper competition, is shown giving the undergraduate first prize to Samuel J. Harris, III, Virginia Polytechnic Institute, for his paper "Determination of Pressure Drag on Bodies of Revolution in Transient Flight."**

Photographed on ¼ in. graph paper

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4.0	1	1⅛
5.0	1 1/32	1⅛
6.0	1¼	1⅛
7.0	1 5/16	1⅛
8.0	1 23/64	1⅛
9.0	1½	1⅛
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.75	⅝	¾
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Second Middle Atlantic Region Conference Held May 3 and 4
Six Schools Participate; U. of Virginia Student Branch Host

THE second Middle Atlantic Region Student Conference, held at the University of Virginia May 3 and 4, was attended by representatives of six schools. Participants were the University of Maryland, Pennsylvania State University, Virginia Polytechnic Institute, West Virginia University, Catholic University, and the host school.

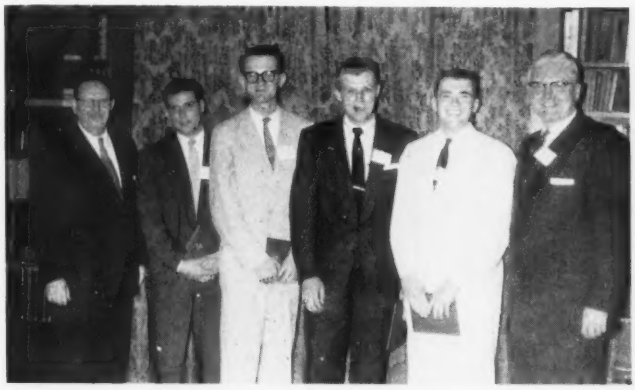
University of Virginia Branch Chairman Robert J. Pauly presided over the conference at which 12 papers were presented during two technical sessions.

Allan Pope, Chief Aerodynamicist, Sandia Corporation, was guest speaker at a banquet in the Monticello Hotel, May 3. He discussed the history and development of this country's atomic weapons.

Mr. Pope also judged the paper competition assisted by Winfield H. Arata, Jr., Chief Operations Engineer, Fairchild Engine and Airplane Corporation, and Carl B. Palmer, Aeronautical Research Scientist, NACA.

After the banquet, conference participants, judges, and faculty members adjourned to the Engineers Club, where a social gathering sponsored by the hosting Student Branch terminated the day's activities in an atmosphere of pleasant reminiscing and discussions concerning the conference.

At the close of the technical sessions, the judges held their deliberations, during which the subject of the 1958 Middle Atlantic Conference was opened for discussion from the floor. It was decided by unanimous agreement to accept the offer of the Pennsylvania State University Student Branch to act as host for the coming year. After a round of thanks to the University of Virginia Student Branch and Faculty Adviser James E. May (for their successful planning and operation of this year's conference), the judges returned to announce the winners. Prizes were presented to the following winners by Mr. Pope:



Line-up of winners waiting to receive prizes from Allan Pope, Chief Aerodynamicist, Sandia Corp., is seen at the University of Virginia during the Middle Atlantic Conference. *Left to right:* Mr. Pope, F. Wendell Johnson, Virginia Polytechnic Institute; T. W. Finch and W. S. Haney, University of Maryland; J. C. South, V.P.I.; and J. B. Cobb, University of Virginia.

First—F. Wendell Johnson, V.P.I., "An Investigation of the Modified Newtonian-Type Flow Over a Flat Plate."

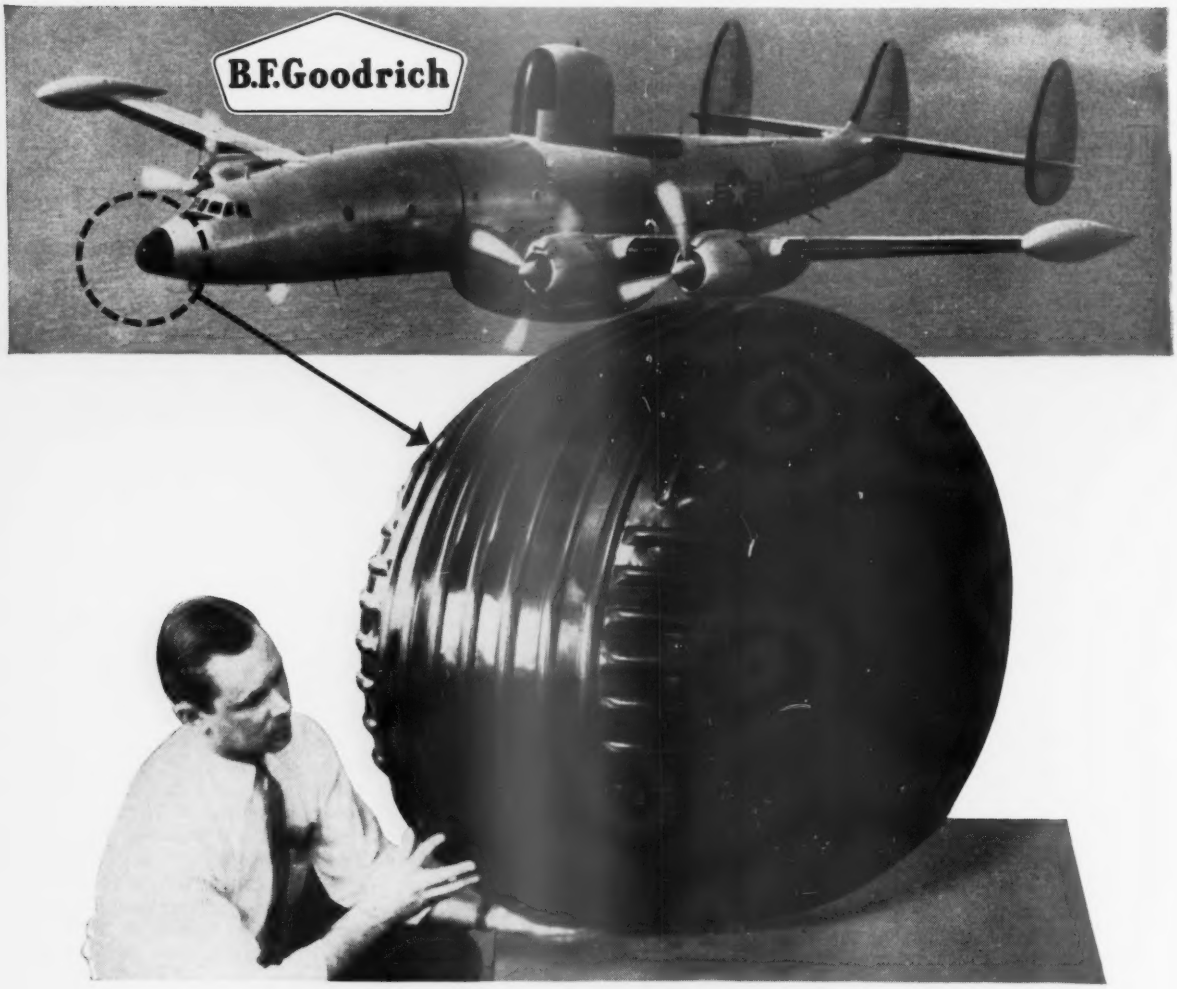
Second—T. W. Finch and W. S. Haney, University of Maryland, "Intersurface Interference Effects for Various Cruciform Delta Wings at Angles of Attack and Roll."

Third—(a tie) J. B. Cobb and A. E. Foster, University of Virginia, "A Discussion of Performance of the Conway By-Pass Engine," and Jerry C. South, Jr., V.P.I., "An Investigation of Modified Newtonian Hypersonic Theory in the Stagnation Region of Cylindrical and Hemispherical Bodies."

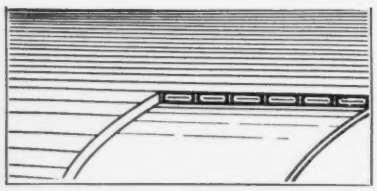
The conference was attended by some 75 students, faculty representatives, and their guests.

JOHN K. HALEN, *Chairman*
University of Virginia
Student Branch

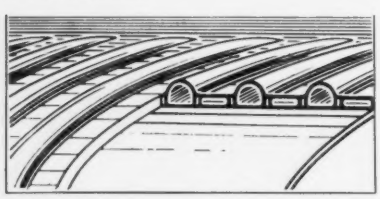
Student engineers who participated in the second Middle Atlantic Student Conference posed for this picture on the campus of the University of Virginia. IAS Student Branches of six colleges were represented.



Pneumatic De-Icers keep radomes clear without distorting radar signal



Shown in relaxed position De-Icer's small rubberized fabric tubes are in line with the airstream to provide minimum air resistance during operation.



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Southeastern Conference Draws 8 Schools, 22 Papers; Atlanta Section Sponsors Annual Student Competition

The eighth Southeastern Region Student Conference was held in Atlanta April 18 and 19, the Student Branch of North Carolina State College acting as host and the IAS Atlanta Section as sponsor.

Joint support for the conference came from Allison Aeroproducts Division, General Motors Corporation; Lockheed Aircraft Corporation; Delta Airlines, Inc.; and Hayes Aircraft Corporation.

More than 160 students and faculty members took part in the program which began with registration at the Peachtree-On-Peachtree Hotel, Wednesday evening April 17. A total of 22 graduate and undergraduate papers were given by representatives of eight participating schools at the Georgia Institute of Technology.

The winners and titles of their papers were:

Undergraduate Division: First prize—J. E. Wallace, North Carolina State, "A Consideration of Stall Flutter in Axial-Flow Compressor Blades." Second prize—C. R. Wilson, Virginia Polytechnic Institute, "Determination of the Aerodynamic Characteristics of Bodies of Revolution in an Axially Symmetric Perfect Fluid Flow by the Method of Vortex Ring Distribution." Third prize—Samuel J. Harris, III, V.P.I., "A Study of Skin Friction Variation Under Transient Conditions."

Graduate Division: First prize—A. L. Wittwer, University of Kentucky, "Anthropometric Contourometry." Second prize—I. M. Moon, Mississippi State College, "Boundary-Layer Control by Distributed Suction on a Wide Angle Conical Diffuser."

Four student engineers whose papers won top prizes in the undergraduate and graduate divisions at the Southeastern Student Conference are flanked by two of Lockheed Aircraft Corporation's professional engineers. *Left to right:* R. W. Middlewood, Lockheed Chief Engineer; A. L. Wittwer, University of Kentucky; J. E. Wallace, North Carolina State College; C. R. Wilson, Virginia Polytechnic Institute; Samuel J. Harris, III, V.P.I.; and A. C. Kotchian, Vice-President, Lockheed Georgia Division.

High points on the conference program were a luncheon at Georgia Tech dining hall with welcoming address and informal comments by R. M. Pinkerton, Professor, North Carolina State; an informal supper and dance given by the Emory University Anchora Club Sorority and faculty; field trips; and the awards banquet. Delegates had a choice of trips to Lockheed or Delta facilities on Friday afternoon, April 19.

The awards banquet was held at the Cherokee Town and Country Club and featured a talk by Igor I. Sikorsky, Consultant, United Aircraft Corporation's Sikorsky Aircraft Division. He discussed "The Present and Future of the Helicopter." David J. Pierce, Branch Chairman, North Carolina State, presided and introduced chairmen of seven other Branches. Robert F. Stoessel, Manager—Sales Engineering, Lockheed, introduced Mr. Sikorsky.

Mr. Sikorsky described the 30 years he devoted to conventional aircraft and then told the story of the VS300, a 100-hp. single-engined helicopter built in 1941.

Helicopters have definite limitations, he said. They are fairly slow and cannot approach the efficiency of cargo aircraft. The great advantages are their ability to take up, hover in the air motionless, or control speed anyway needed and their ability to pick up a load of any size.

He said there are three main "virtues" of helicopters which will in time greatly extend their use:

(1) Transfer of cargo and passengers, 15 to 40 miles, between jet age airports and centers of population.

(2) Outstanding lifting characteristics (helicopter cranes), limited only by weight, not by bulk of cargo.

(3) The best possible instrument for saving human life under the greatest variety of conditions. (Here he cited instances of its use in floods in Connecticut and Mexico.)

Mr. Sikorsky concluded by prophesying a "tremendous" future for helicopters which the audience, he said, would see.

Part of the Southeastern Student Conference program was a visit to facilities of Lockheed Aircraft Corp. Some 90 students went on this field trip. Those in the photo are listening to Jack Foster of Lockheed explain the workings of a miniature F-104 Starfighter. Students are *(left to right)* Arno Kallaste, Gene Brown, Richmond Boyden, Bill Shearer, Cecil Palmer, Donald Boatwright, and L. E. Clemmer.

EDITH H. LIVELY
Publicity Chairman
Atlanta Section

"ECLIPSE" a recent painting by Simpson-Middleman, gifted artistic interpreters of the physical sciences. About this new expression they write: "'Eclipse' was painted as a result of watching an actual eclipse of the sun. We were particularly struck with the curious light that was both dim and glowing and the unusual pattern of the shadows on the leaves of the trees around us. We had never seen anything like it before." Painting courtesy of John Heller Gallery, Inc.

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Engineering and Scientific Briefs from Correspondents Around the Globe

Antonov Reveals U.S.S.R. Is Seeking Artillery Spotter

◆ First indication of a competition in the U.S.S.R. for an artillery spotter came recently in a reported interview with the Soviet designer, O. K. Antonov. Antonov discussed the latest model of the AN-2, said by him to be "the NRK, which at present exists in prototype form only." He was quoted as observing further:

"This development has been produced to compete in a military contest for a slow-flying artillery fire-control and reconnaissance aircraft, and it is currently being evaluated against designs by A. S. Yakovlev and P. O. Sukhoi. The NRK has a twin fin-and-rubber assembly in place of the normal single vertical tail surface so that a tail turret housing a single 23-mm. cannon could be installed."

It is probable that Yakovlev has entered the YAK-11, YAK-12, and/or YAK-18. Sukhoi, on the other hand, is not known to have an existent design of this type, thus it is possible that he has proposed a new design especially for this competition.

High-Purity Chromium Manufactured by Japanese

◆ It has been reported that the Government Mechanical Laboratory, under the Agency of Industrial Science and Technology of Japan, has succeeded in the trial manufacture of high-grade chromium.

According to the report, an electrolytic method is employed using chromic acid and is followed by reduction of hydrogen gas at 1,450°–1,500°C. Metal impurities (amounts not reported) found were iron, silicon, magnesium, and copper. However, the gas impurities were relatively low, with nitrogen reported as 0.004 per cent and oxygen as 0.01 per cent. Satisfactory workability is claimed at this stage although the project reportedly has just begun.

The Japanese metallurgists are, to every appearance, cognizant of all the factors responsible for the embrittlement of chromium and chromium-base alloys since they seem to have found a method to reduce nitrogen to a minimum.

The development of a ductile chromium-base alloy could be significant in the manufacture of turbine buckets having higher allowable operating temperatures.

Note on a Tabletop Wind Tunnel for Study of Supersonic Flow

Lewis Dewart, IV*

Sunbury Daily Item, Sunbury, Pa.

In the belief that actual construction would answer conclusively many questions, including costs, involved in fabricating a miniature supersonic wind tunnel, the author undertook the task suggested by Powers.** It was also desired, of course, to determine if it was possible for one not especially skilled in such work to carry it through to a successful conclusion. In this connection, IAS Student Branches came to mind. Such a project is heartily recommended to those preparing for careers in aeronautical engineering.

In both of these basic aims, the hope was for at least fair results; instead, as evidenced in part by the accompanying Figures, they would seem to border on the excellent. A small, inexpensive, and efficient miniature supersonic wind tunnel was created. It is capable of operation at no cost in the workshop or in the living room. The cost was under $10. Spare-time hours required totaled about 150.

Fig. 1 shows the device on a base plate, which measures 26 in. long by 8 in. wide. Weight, including the oak base, is 7 lbs.

* Production Manager.

** Powers, Patrick W., *A Miniature Supersonic Wind Tunnel*, Aeronautical Engineering Review, Vol. 11, No. 12, pp. 38–42, December, 1952.

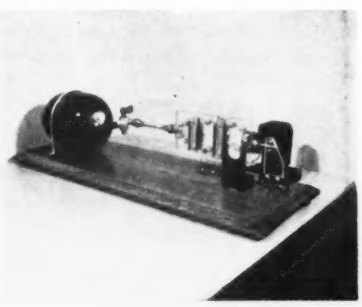

FIG. 1.

FIG. 2.

Fig. 2 is a magnification of a Mach 1.7 flow recorded by an optical system. The system consists of a point light source, light shield, and lens to enlarge the shadow of the flow on the screen. For photographic purposes, a film plate is substituted for the screen, and the light source is triggered with one hand while the other opens a flow valve.

The main design features were determined by Powers, and the first efforts of the author were directed toward procurement of the necessary materials. What these were may be determined by a description of Fig. 1.

The air reservoir, filler nipple, and pressure gage were taken from a walk-around oxygen bottle, the filler nipple being welded into the base of the tank. The operating valve is of the 90° plug type and was taken from a gas stove. The inlet pipe from the operating valve to the tunnel settling chamber is a short section of an aircraft hydraulic line.

The only actual machining on the system was necessary to insert the hydraulic nipple into the clear plastic tunnel. The clear plastic portion of the tunnel shown is identical to that described by Powers except that the side walls are reinforced with steel aircraft channel.

The nozzle blocks were cut by jig saw, placed side by side, and worked to proper dimensions and mirror finish with files, sand paper, and a mixture of cleansing powder and water. The model support was constructed of clear plastic and is so mounted that the model may be brought into proper adjustment within the test section.

(Continued on page 33)

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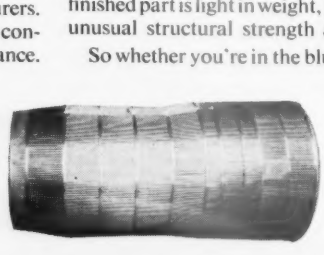
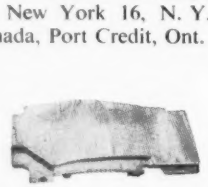

Insulated Engine Shroud


Insulated Structural Part

Johns-Manville PRODUCTS FOR THE AVIATION INDUSTRY

Air is brought up to pressure in the tank with a small bore hand tire pump, and it is possible to obtain about 100 psig in the reservoir. This permits a short blast of supersonic flow of about 1 sec. duration.

Models are made from short lengths of music wire, inserted in a drill chuck in the cases of bodies of revolution and worked to shape with files and emery cloth. The model in Fig. 2 is a cone on cylinder. Some miniature airfoil sections of brass, soldered to music wire stings, are being made.

The supersonic nozzle has a throat height of 0.089 in. and a width of 0.189 in. The test section height is 0.128 in. with the side walls open to the atmosphere. Gentle contour forms the lines from throat to test area. The width of the throat was dictated by the thickness of clear plastic sheet available.

The design Mach Number was 1.8, and the apparent Mach Number which has been obtained is 1.7—the limitation being due, of course, to pressure obtainable by the hand pump.

2.7 Gram Transformer Developed by East Germans

◆ An East German Communications journal reports that VEB Entwicklungswerk Funkmechanik (Development Plant for Radio Devices) at Leipzig-Plagwitz has developed a miniature transformer, 10 by 10 by 10 mm. in size and weighing only 2.7 grams. The fine copper wires, 0.012 to 0.05 mm. in diameter, are manufactured by VEB Kabelwerk Koepenick. The core frame is made of type 31 pressed material; the sheets are stamped and made of either Permenorm or Mumetal, 0.1 to 0.35 mm. thick, according to electrical requirements.

The new transformer was developed in two designs, with the following electrical values. It was to be used in amplifier circuits using junction transistors for applications such as hearing aids. (See Table 1.)

The second size is designed for use with the OC-810 and OC-811 transistors manufactured by the VEB Werk Fuer Baulemente der Nachrichtentechnik, Teltow. Three additional sizes are now being developed.

The foregoing is an indication of the progress being made by East German electronics firms in the field of component miniaturization.

New German Airship Powered by U.S. Engine

◆ A U.S. engine of 215 hp. reportedly gives a cruising speed of about 40 knots to West Germany's first postwar airship, which has been launched at Stuttgart.

The airship is said to have a service ceiling of 6,500 ft. It is filled with 180,000 cu.ft. of hydrogen.

The development may be indicative of future West German interest in the nonrigid airship field.

Italian Rockets to Aid Developments by Japanese

◆ The Japanese plan to purchase 400 unguided aircraft rockets and proximity fuses from the Stachini Company of Italy for design and production studies. The Italian rocket is reported to have characteristics similar to the Oerlikon rocket produced by the Swiss Company.

The use of these 400 rockets is intended to give the Japanese a start on their development program. Although wholly new designs may not be developed by the Technical Research Institute, slight variations of the design in order to attain a greater ease of manufacture may be tested to determine how these changes affect flight characteristics. It is planned to have a rocket design ready for a trial manufacture by 1958. Therefore little change in the basic design may be expected.

Article Reports Acceleration of Soviet Scientific Activity

◆ A recent Soviet article reviewing the history and progress of the Central Scientific Research Institute of Technology and Machine Construction attests to the acceleration of efforts and scope of scientific activity in the U.S.S.R. since 1945. For example, in the field of new machine-construction materials the following specific achievements are noted:

(1) In the development of new heat-resistant materials, basic research sponsored by the Institute established some general principles for producing alloys suitable for stationary steam or gas turbines operating at temperatures at which creep and relaxation become controlling factors in the service life of the turbines. This work resulted in the development of the following new alloys:

(a) A heat-resistant low-cobalt steel, A-1, for castings used in steam turbines designated as CBK-150. A modification of this steel with improved resistance to intercrystalline corrosion is now used for cast parts in gas turbines operating at 650°C. (1,200°F.). The improved alloy is designated A-4.

(b) A pearlitic steel for service under conditions of relaxation at 550°C. (1,020°F.). This steel is used for fastenings.

(c) A fastener and turbine-blade material for service at 700–750°C. (1,290–1,380°F.).

(2) A microelectrochemical method for the investigation of stress-corrosion cracking of metals in corrosive environments. This method has been found to be very useful in the development of new alloys for special applications.

(3) A method for testing the erosion resistance of turbine blades having a chemically treated surface in order to increase their erosion resistance. This appears to be a promising treatment for gas turbines operating on solid fuel.

(4) The first austenitic-steel welded rotor for a gas turbine has been installed in a Soviet power plant. This installation is experimental, based on laboratory tests. If it is successful, welded rotors will be widely used in future installations.

(5) Methods for the surface protection of heat-resistant pearlitic and austenitic steels by the diffusion of alloying elements.

In the field of quality control, the Institute developed testing machines for static tensile tests (up to 120-ton capacity); fatigue-testing machines for specimens up to 200 mm. (8 in.) in diameter; high-temperature [up to 800°C. (1,470°F.)] testing machines for tensile, corrosion-fatigue, and scaling-resistance tests; special testing machines for creep testing turbine blades, discs, rotors, and cylinders under simulated service conditions. The Institute also developed magnetic defectoscopes—a luminescent method for gamma-ray defectoscopy that has been found to be useful for turbine castings, welded joints, etc.—and ultrasonic defectoscopes which are now finding ever-expanding uses in heavy machine construction, ferrous metallurgy, chemical machinery, etc.

Australian Discovery Shrinks Continent

◆ The Australian Department of External Affairs recently announced the discovery of a large glacier 30 miles wide and well over 100 miles long. This has led scientists to believe that what was previously mapped as a part of the continent, in the vicinity of Mount Christianson in Enderby Land, is actually a large island.

TABLE 1

Property	First Size	Second Size
Primary impedance	60 kilohms	30 kilohms
Secondary impedance	800 ohms	2.5 kilohms
Lower frequency limit	350 cps	260 cps
Upper frequency limit	over 15 K cps	over 30 K cps

GUEST EDITORIAL

by Courtland D. Perkins

Chief Scientist, U.S. Air Force*

The Young Engineer Looks Ahead

Excerpts from an address given at a dinner for the IAS Northeastern Region Student Conference at Princeton University, March 30, 1957. The following constitutes the "philosophical" portions of the address to the student. Professor Perkins ended his talk with a discussion of some of the technological problems (unclassified) with which U.S. Air Force Research and Development is now dealing, terminating with a short film showing some of the items of "hardware" that have recently been declassified.

I am very pleased to have an opportunity to discuss with you some of the problems in research and development facing the Armed Forces and the opportunities that these problems develop for your generation of young aeronautical engineers. . . .

The major demand for the young aeronautical engineer or scientist will be generated directly or indirectly by the Armed Forces. The chance of operating in this field without working either directly or indirectly for one or the other of the Armed Forces is quite small. He should therefore be considerably interested in the short- and long-range planning within the Department of Defense and a study of how this planning may affect his career in the future. . . .

A young aeronautical engineer or scientist viewing his future prospects is immediately presented with a colossus—namely, the aeronautical industry as it is now poised ready to produce weapon systems for the Armed Forces. This industry not only is one of our

* On leave from the Department of Aeronautical Engineering, Princeton University.

largest but is quite unique in that it is probably the only one that is almost completely focused on satisfying the demands of our Armed Forces. This industry is supported through a defense budget of tremendous size, and its production capacity is geared to the needs of the Army, Navy, and the Air Force. It is an industry whose technological background continues to grow more and more complex as time goes on and whose products become more and more costly to the country at large. The production of any one element of this industry is subject to accelerations and decelerations as new technological breakthroughs reorient our defense needs and as intelligence information from the Soviet Union indicates strength or weakness.

These facts may lead the young aeronautical scientist to believe that he is dealing with an extremely unstable field and one with which he should avoid getting involved at all costs. The practical situation, however, insofar as the aeronautical engineer is concerned is much more stable than I have indicated. Although the production of one weapon or another may be accelerated or decelerated, there has been only a steady growth in the engineering side of this field ever since the start of World War II. The young engineer should therefore not confuse this production instability with lack of continuity in our engineering effort. Our need for young aeronautical engineers and scientists is still tremendous and unquestionably will continue to be so for the foreseeable future.

An example of this change in technology is the upsurge in development of the guided missile. The Armed Forces are spending this year almost 50 per cent of their budget for new hardware on guided missiles, and this will unquestionably reduce, to a certain degree, the number of man-carrying airplane systems. However, it appears that manned aircraft will be with us for the foreseeable future. Although this change in technology may result in somewhat different industrial activity, it has by no means reduced the total requirement on our engineering manpower. The fact of the matter is this demand keeps increasing all the time but the emphasis keeps shifting into the more advanced fields.

The young engineer then entering the aeronautical field must be prepared to work in a technical climate that is developing at tremendous speed. He will find himself hard-pressed to keep up with all the advances. He must not become worried as one technical breakthrough or another changes the whole complexion of this field but must be flexible enough to roll with each punch and actually help lead the industry and the Armed Forces into areas of higher capability. It is certainly not a static field but rather a very dynamic one in which the usual industrial pattern of stability exists only to a small extent. This fact can be viewed as an ultimate advantage to the young engineer and will add up to a maximum of job interest and financial return. This is a very large and fascinating industry within which the young engineer must learn to operate.

Once the young engineer or scientist has achieved a proper perspective of the aircraft industry he should examine the major force that keeps this industry operating at top effort. This force is, of course, our technological race with Soviet Russia which we must not lose if we hope to maintain our military posture as a deterrent to the big war.

I don't think it comes as any news to you that we are not standing in a very good position with respect to the Russians in some aspects of this race—one of the most important of which is the supply of technical manpower. Most of you have heard many commentaries on the Russian educational scene. One of the most important comments lately is that of Dr. Edward Teller of the University of California, Livermore Laboratories, who stated: "We have already lost this race." What he means by this is that the Russians started expanding their technical education system some 5 or 6 years ago and that the first fruits of this large emphasis on technical and scientific education are just beginning to be harvested. He mentioned that if we were to start now it would still take about 6 or 7 years for the program to build up and by that time we would be quite a bit behind the Russians.

What we really don't know, of course, is the real quality of this large number of scientists and technicians the Russians are turning out. We suspect that the quality is very high indeed. Although I do not feel that things may be as hopeless as Dr. Teller stated, nevertheless, we are confronted with a very serious problem with regard to our technical manpower. I can assure you this is presenting to you people an important immediate problem.

Young engineers and scientists who will be immediately thrown into this technical race with the Russians are going to be handicapped by lack of numbers, say on the order of two to one. This, as you all know, can be overcome by ensuring a very high quality in the work you do and suggests immediately that as many young engineers as possible proceed on to higher education at least to the Master's degree level. It is true we need as many technically qualified men as possible to fill the routine jobs in the engineering fields. It is here that we are going to suffer in the "numbers racket." A large part of this can be offset, however, if we develop a very large number of extremely capable young engineers whose ingenuity in concept and design will make it unnecessary for us to have so many of the routine type engineers that work today in many areas. We are tending to smother our problems with money and manpower resulting in a waste of our engineering effort. This fault can be overcome only by an increase in the number of very highly qualified engineers and scientists who are directing programs toward their simplest effective solution.

If we do things the hard way we will never be able to keep up with the Russians. The situation is quite similar to the Army's problem of fielding a force of the same number of divisions as the Russians. It just can't be done, for they have too many men for us. However, we can concentrate on high quality and high

ingenuity which will make our smaller numbers more effective. We are presently in that position with respect to the engineers and scientists. We must make sure that all of you are as highly trained as possible, and I cannot concentrate too much on the need for ingenuity of thought and approach in solving engineering problems. We just cannot afford to squander young engineers on doing things the hard way. If we do, we are bound to lose more ground to our potential enemy, the Soviet Union.

Besides the manpower problems vis-à-vis Soviet Russia, we also have the budget problem. At the present time we are operating on a stabilized budget that will permit us only a certain number of new developments each year. The Russians, on the other hand, in the area of research and development, seem to operate with an unlimited budget and can start and continue toward development any project that appears to be of any interest to the Armed Forces. Our view is more restricted, and perhaps properly so, because of the desire of our Government to maintain the highest standard of living possible for our people, while at the same time maintaining a military force sufficient to deter war. This requires that our whole development program be made up of only those projects that have real chance of success. We cannot afford to develop every system conceived in order to make sure we don't miss any good bets. We must be especially skilled in the selection of our most promising weapon systems in the very early stages of their development so that we can afford financially to carry them through sufficient development to estimate reasonably their military value.

In order to solve these sticky problems, we need brilliant men strategically placed through the industry, throughout the research organizations, throughout the universities, throughout the Armed Forces. The opportunities for such men within our present systems are absolutely limitless, and I can only recommend to you that you prepare yourselves to the absolute maximum of your potentialities to take advantage of this situation. The safety of our country depends on men of your generation recognizing these problems, training themselves to the absolute maximum of their abilities, and then attacking rapidly the problems confronting us with as much vigor and as much ingenuity as is humanly possible.

This seems to me to be our only salvation for proper technological contest with the Soviet Union. The young aeronautical engineer takes his part in an enormously large and complex industry in which the opportunities for ingenuity and brilliance are rewarding in the extreme, not only from the financial point of view but from the more satisfying feeling that it deals entirely with the defense of our country. Right now it is our ingenuity versus that of the Russians, and it will be a sad day for the freedom of this country if we get too far behind. . . .

▲ ▲ ▲

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The hazards of meteoric dust for space flight are reviewed, and it is indicated that for short-lived vehicles the hazard is negligible.

Meteoric Dust Erosion Problem and Its Effect on the Earth Satellite

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The Problem

It is not many years since the erosion problem involved only the effects of rain on high-speed airplanes. Now the designer of space satellites must deal with the endless rain of microscopic particles that await his vehicle, in space, beyond the protection of the earth's atmosphere. These particles are presumably the debris of broken planets or asteroids or may be composed of ice-stone mixtures which have been stabilized by the intense cold of space. No doubt all three types are present, but the iron meteorites, so much more durable than the stony type, are much more commonly found. The danger from such meteors lies more in the very small rather than in the larger sizes since the number of meteors increases rapidly as the diameter decreases.

The major problem in any study of meteoric hazards is making an accurate evaluation of the numbers and sizes of particles entering the earth's atmosphere from outer space. The difficulty in arriving at a good estimate of the daily flux of meteors arises for a number of reasons:

(1) Meteors can be observed only when they enter the earth's atmosphere and begin to leave a trail of ionized gases behind them. This trail of ionized gases is due to both ablation and shock-wave heating of air through which the meteor passes. Since the beginning of this trail is hard to observe and varies considerably in altitude with meteor mass and velocity, the meteor trajectory is extremely difficult to define exactly.

(2) The relation between the magnitude of the meteor (the total light emitted) and the meteor mass and velocity is still a matter of study. The work of Öpik[1] and Hawkins[2] are typical examples of present thinking on these matters and of the results obtained.

Recently, meteor trails have been observed by the techniques of radio astronomy. In this method radar waves are reflected from the column of ionized gases behind the meteor. The "Doppler shift" of the reflected radar waves is then used to determine the meteor direction and velocity. In general, the results have confirmed the photographic data although the overlap of the techniques is limited. Papers by Pawsey and Bracewell[3] and McKinley[4] are good examples of recent results.

Previous Work

One of the early papers in the literature on the danger to space ships from meteors was written by Grimminger.[5] He took the existing meteoric data and extrapolated it to sizes of meteoric dust particles too small to be observed by any method. From this analysis, he concluded that, if all particles 1 micron in diameter or larger were considered, a space ship having a total area of 1,000 ft.^{2} would receive about 450 hits per hour. Ovenden[6] considered the problem under similar conditions and reached substantially the same conclusions.

The two basic problems in all analyses of this type are (1) obtaining a correct value for the daily flux of meteors too small to be observed and (2) finding a law of penetration for very high-speed particles. The method used in estimating the numbers of meteors too small to be observed involves the extrapolation of the available data according to a law of the form[5]

$$N = N_0(10)^{2/5\,(M - M_0)}$$

where N_0 is the number of meteors of apparent magnitude M_0, and N is the number of magnitude M. M increases as the mass of the meteor decreases according

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TABLE 1
The Number, Mass, and Size of Meteorites Entering the Atmosphere Each Day[5]

Visual mag. M	Observed No.	True No. N	Mass m, grams	Diam. of equiv. sphere d, cm
-3	28,000	28,000	4.0	1.30
-2	71,000	71,000	1.6	9.66×10^{-1}
-1	180,000	180,000	0.630	7.07×10^{-1}
0	450,000	450,000	0.250	5.20×10^{-1}
1	1,100,000	1,100,000	0.100	3.83×10^{-1}
2	2,800,000	2,800,000	0.040	2.81×10^{-1}
3	6,400,000	7,100,000	0.016	2.08×10^{-1}
4	9,000,000	18,000,000	0.0063	1.52×10^{-1}
5	5,600,000	45,000,000	0.0025	1.12×10^{-1}
6		110×10^6	0.0010	8.24×10^{-2}
7		280×10^6	0.00040	6.05×10^{-2}
8		710×10^6	0.00016	4.48×10^{-2}
9		18×10^8	0.000063	3.29×10^{-2}
10		45×10^8	0.000025	2.42×10^{-2}
15		45×10^{10}	2.5×10^{-7}	5.20×10^{-3}
20		45×10^{12}	2.5×10^{-9}	1.20×10^{-3}
25		45×10^{14}	2.5×10^{-11}	2.42×10^{-4}
30		45×10^{16}	2.5×10^{-13}	5.20×10^{-5}

to a law of the form (reference 7, page 33)

$$M = C_1 - \log_{10} C_2 m / C_3$$

where m is the mass of the meteor, and C_1, C_2, and C_3 are constants for any particular meteor velocity.

In an estimate of the number of meteors too small to be observed, it is assumed that this type of law is correct for all sizes of particles. Using this relation, an estimate of number of particles down to visual magnitudes of 30 can be made. The magnitude scale, which is used by astronomers to relate the brightness of various bodies, is logarithmic. In general, the difference in magnitude between two objects is related by the formula

$$M_2 - M_1 = 2.5 \log (I_1/I_2)$$

where M represents magnitude and I brightness. For example, on the apparent scale, the brightness of the sun is rated at magnitude -26.7 while the faintest known star has a magnitude of $+22$.[8]

The calculation is stopped at magnitude 30 because particles smaller than this will probably be swept out of the solar system by the pressure of solar radiation; but it is conceivable that a highly energetic particle on a hyperbolic or parabolic orbit might make one trip through the solar system against the pressure of solar radiation.

There is, however, a still more powerful mechanism which may be responsible for this removal of meteoric dust from the solar system. A small, high-speed particle will receive radiant energy from the sun and will in turn reradiate such energy. It can be shown that this emission will tend to reduce the velocity of such a particle and, therefore, its energy. Under such conditions a particle will gradually spiral into the sun and be destroyed. An evaluation of this effect by Wyatt and Whipple[9] indicated that all particles less than about 0.032 in. in diameter would be swept into the sun over reasonable geological periods of time. If such an effect is indeed present, the probability of a small meteor striking an earth satellite may be considerably reduced.

Even if such a cleansing of particles in solar orbits occurs, there is a possibility that meteoric dust might accumulate in orbits about the earth. This is being considered by the author at the present time, and preliminary calculations (unpublished) have indicated that a certain fraction of the daily flux of meteors will pass through the earth's upper atmosphere with such velocity and direction that they lose sufficient energy to become permanent satellites of the earth. Such satellites orbiting at altitudes of about 6,000 miles might be a contribution to the Gegenschein or sky glow. It has been postulated by Schmidt in reference 10, page 460, that this sky glow is indeed due to a dust cloud which encloses the earth and is illuminated by the sun.

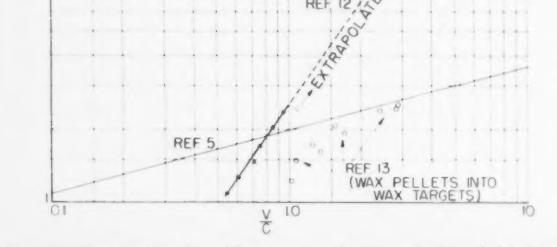

FIG. 1. Penetration in calibers vs. projectile velocity divided by target sound velocity.

EFFECTS OF METEORIC IMPACT

Penetration Theory

The interaction of a tiny particle traveling at about 30 miles per sec., with a metallic surface, is a complicated problem. Up to the present time no experimental techniques exist for laboratory research in this velocity range, and all work has been purely theoretical.

In reference 5 the results of a number of investigations were used as a basis for an extrapolation of the theory of penetration to the meteoric velocities. The results of this extrapolation yielded a formula of the form

$$T/d = 1.62 \log_{10}(V_1/5{,}000) + 1.10$$

for stony meteors striking dural, where T and d are the depth of penetration and particle diameter, respectively, in inches, while V_1 is the incident particle velocity in ft./sec. This indicates that a stony projectile 0.01 in. in diameter traveling at 70,000 ft./sec.

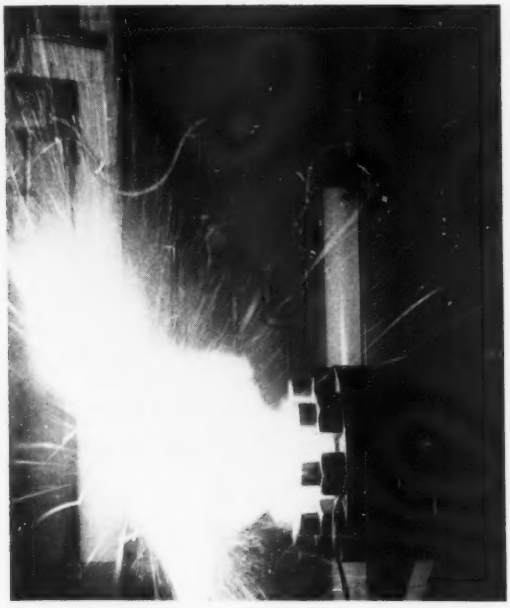

FIG. 2. Shock tube firing at an aluminum plate.

would penetrate a dural sheet whose thickness is equal to about 3 particle diameters. (For the convenience of the reader, the data of reference 5 on the number of meteors observed, magnitude, etc., is reproduced as Table 1.)

Since the work of reference 5 represented a tremendous extrapolation of the available data, other investigators have used different approaches. Singer[11] has considered the impact of micrometeorites on metal surfaces for a number of different types of surface particle interaction—i.e., sputtering, sublimation, and fragmentation. He concludes that the disparity between the estimates of these processes is such that no good estimate can be made at this time.

RECENT EXPERIMENTS ON PENETRATION

Since the theory of penetration alone is not sufficiently developed at this time, there have been extensive experiments by a number of investigators. Huth, Clay, and others[12, 13] have used shaped charges and guns to accelerate small metal spheres and cylinders to velocities as high as 16,400 ft./sec. While this is still far below average meteor velocities, it probably represents almost the highest macroscopic particle velocities that can be produced by current techniques. The work of reference 12 yielded results in the form of a penetration formula for targets and projectiles of the same material.

$$T/d = 2.5(V_1/C)^{1.4} \qquad 0.1 \leqslant V_1/C \leqslant 1.0$$

where T and d are as before the depth of penetration and projectile diameter, respectively, while V_1 and C are the incident projectile velocity and target speed of sound defined by $C = \sqrt{E/\rho}$, where E represents Young's modulus and ρ the density.

In reference 13 the penetration of small spheres into plates was investigated for $1 \leqslant V/C \leqslant 3$. The technique used involved firing wax pellets into wax targets. The results of these investigations are plotted together in Fig. 1 for similar conditions. While the agreement in general is poor, it must be noted that the penetration formula of reference 12 was not expected by the authors to be valid above V/C ratios of 1; therefore, it is plotted only for reference purposes.

The work of references 12 and 13 dealt with particles 1/8-in. in diameter or larger, and experiments on the effect of fine dust particles of the order of 5×10^{-3} in. in diameter have not been done to the author's knowledge.

FUTURE PLANS

At the Armour Research Foundation, studies have been made on the feasibility of using a modification of Hertzberg's Shock Tunnel[14] to accelerate fine dust particles from 0.003 to 0.0156 in. in diameter to velocities as high as 13,000 ft./sec. for erosion studies.

While this too is far below true meteor velocities, an experiment of this type will permit separation of the aerodynamic and ballistic effects for dust particles at high velocities. This is of importance for flight in the upper atmosphere, where, even though the air is thin, the shock wave on the vehicle can still affect the trajectories of light dust particles in the vehicle path.

In evaluating the feasibility of this method, one of the Foundation's shock tubes was used to fire iron dust at an aluminum plate at about 4,000 ft./sec. Photographs of the shock tube firing at the aluminum plate and the plate after the shot are shown in Figs. 2 and 3.

FIG. 3. Aluminum plate after one shot.

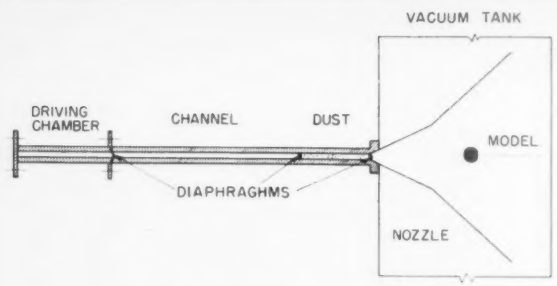

FIG. 4. Hypersonic dust tunnel.

A schematic drawing of the proposed facility is shown in Fig. 4 where the two-section nozzle will be used to lower the pressure of the driving gas in the nozzle to about 0.1 micron of mercury. This in turn will allow separation of aerodynamic from ballistic effects by weakening the shock wave on the test model.

Efforts are under way at the Foundation to develop techniques for accelerating dust to velocities as high as 60,000 ft./sec., but at present these are only in the planning stage.

Singer[11] is planning an erosion experiment for the earth satellite program. He plans to coat a section of the outer surface of the satellite with a radioactive isotope which will emit electrons. The number of electrons per second will in turn be counted by a Geiger counter. As the radioactive material is eroded away by collisions with dust particles, the rate of loss will be measured by the change in the number of electrons received.

Conclusions About the Danger From Meteoric Dust Particles

Until more exact measurements of the daily flux of meteors are made, we must accept the results of references 5, 6, and 15 which indicate that meteors constitute almost no hazard for space flights of short duration—e.g., days. For the case of very large space ships, say, of the solar-powered type suggested by Ehricke[16] or a semipermanent earth satellite, the hazard may well be serious. In either case, optical surfaces and thin Geiger tube windows must be covered at all times when not in use since they will be most prone to damage.

The coming experiments planned for the International Geophysical Year and the continuing work of many organizations will no doubt shed much light on this problem in the future.

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Ken S. Coward*
Ryan Aeronautical Company

Propeller Selection for High Static and Forward Flight Efficiency for VTOL Aircraft

Experimental data are presented which are useful in establishing the boundary conditions in which efficient operation can be obtained for both regimes.

Symbols

C_P = propeller power coefficient = $BHP\ (550)/\rho n^3 D^5$
C_T = propeller thrust coefficient = $T/\rho n^2 D^4$
C_S = speed-power coefficient = $V/nD/C_P{}^{1/5}$
D = propeller diameter, ft.
K_1 = $n_c/n_{T.O.}$
K_2 = $BHP_c/BHP_{T.O.}$
M_t = propeller tip Mach Number
Fig. of merit (0.798) $C_T{}^{3/2}/C_P$
T = propeller static thrust, lb.
n = propeller rotational speed, r.p.s.
V = cruise speed (true), f.p.s.
ρ = ambient density, slugs/ft.^{3}
σ = density ratio

Subscripts

c = cruise
$T.O.$ = take-off

Introduction

There exists a feeling in the industry that propellers designed to give reasonably good static thrust will demonstrate poor efficiency in forward flight. This paper uses experimental data obtained by the NACA[1, 2] to present a method of propeller selection whereby both high static efficiency and high efficiency in forward flight might be realized.

Method of Analysis

The experimental data on propulsive efficiency have been presented as a function of a useful nondimensional coefficient C_S, the speed-power coefficient. This coefficient is simply a means of relating the forward speed, propeller rotational speed, and shaft horsepower so as to present efficiency as a function of the combination of all three. The rotational speed can be solved for as follows:

$$C_S = (V/nD)/C_P{}^{1/5} \quad (1)$$

$$C_{Pc} = BHP_c\ (550)/\rho_c n_c{}^3 D^5 \quad (2)$$

Substituting Eq. (2) in Eq. (1)

$$C_S = V_c \rho_c{}^{1/5}/n_c{}^{2/5}\ \overline{BHP}^{1/5}\ (550)^{1/5}$$

from which

$$n_c = V_c{}^{5/2}\ \rho_c{}^{1/2}/C_S{}^{5/2}\ BHP^{1/2}\ (550)^{1/2} \quad (3)$$

Now, examine the static thrust conditions at take-off:

$$C_{PT.O.} = BHP_{T.O.}\ (550)/\rho_{T.O.}\ n_{T.O.}{}^3\ D^5$$

from which

$$D = BHP_{T.O.}{}^{1/5}\ (550)^{1/5}/\rho_{T.O.}{}^{1/5}\ n_{T.O.}{}^{3/5} C_{PT.O.}{}^{1/5} \quad (4)$$

Now, if we express the cruise conditions in terms of the take-off conditions,

$$n_c = n_{T.O.}\ K_1 \text{ and } BHP_c = BHP_{T.O.}\ K_2$$

Eq. (4) can now be written as

$$D = BHP_c{}^{1/5}\ (3.53) K_1{}^{3/5}/\rho_{T.O.}{}^{1/5} n_c{}^{3/5} C_{PT.O.}{}^{1/5} K_2{}^{1/5} \quad (5)$$

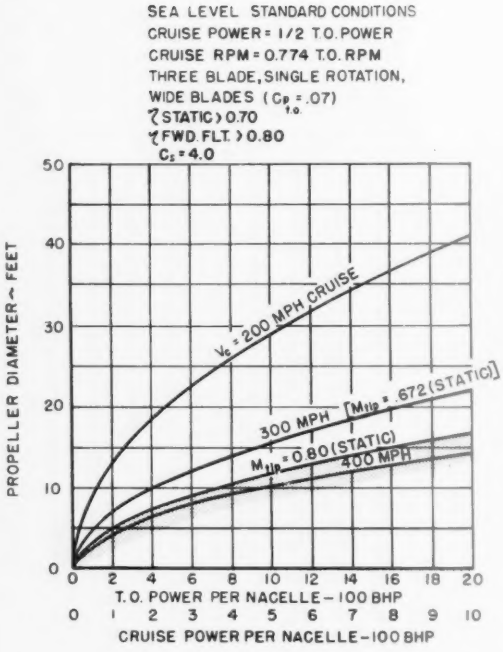
In order to provide for high propulsive efficiency in the forward flight cruise condition, it is now necessary to assign an upper limit to C_S in Eq. (3). Examination of the data[1] reveals that this value will vary between 3 and 4 for an η of 0.83 depending on the propeller configuration.

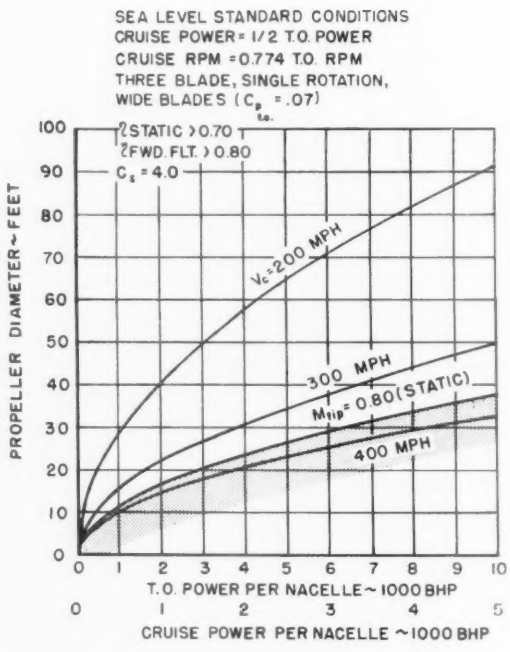
To ensure high static efficiency for take-off, it is necessary to assign values of $C_{PT.O.}$ in Eq. (4) which lie near the value for maximum figure of merit. These values can be obtained from the data[2] by solving for figure of merit at the various propeller blade angles. This value C_P lies between 0.07 for the three-blade, single-rotation propeller and 0.20 for the eight-blade, dual-rotation propeller.

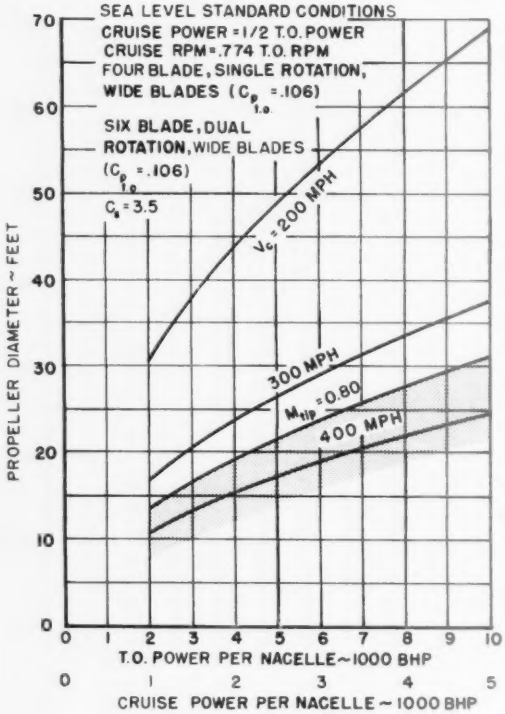
For a particular propeller configuration, these values of C_S and $C_{PT.O.}$ can be substituted in Eqs. (3) and (5), respectively, and the basic expressions are available for plotting useful curves.

The designer can now use any relation between the

* Preliminary Design Engineer.


SEA LEVEL STANDARD CONDITIONS
CRUISE POWER = 1/2 T.O. POWER
CRUISE RPM = 0.774 T.O. RPM
THREE BLADE, SINGLE ROTATION,
WIDE BLADES ($C_{p_{t.o.}}$ = .07)
η STATIC > 0.70
η FWD. FLT. > 0.80
C_s = 4.0
V_c = 200 MPH CRUISE
300 MPH [M_{tip} = .672 (STATIC)]
M_{tip} = 0.80 (STATIC)
400 MPH
PROPELLER DIAMETER ~ FEET
T.O. POWER PER NACELLE ~ 100 BHP
CRUISE POWER PER NACELLE ~ 100 BHP


SEA LEVEL STANDARD CONDITIONS
CRUISE POWER = 1/2 T.O. POWER
CRUISE RPM = 0.774 T.O. RPM
THREE BLADE, SINGLE ROTATION,
WIDE BLADES ($C_{p_{t.o.}}$ = .07)
η STATIC > 0.70
η FWD. FLT. > 0.80
C_s = 4.0
V_c = 200 MPH
300 MPH
M_{tip} = 0.80 (STATIC)
400 MPH
PROPELLER DIAMETER ~ FEET
T.O. POWER PER NACELLE ~ 1000 BHP
CRUISE POWER PER NACELLE ~ 1000 BHP


SEA LEVEL STANDARD CONDITIONS
CRUISE POWER = 1/2 T.O. POWER
CRUISE RPM = .774 T.O. RPM
FOUR BLADE, SINGLE ROTATION,
WIDE BLADES ($C_{p_{t.o.}}$ = .106)
SIX BLADE, DUAL
ROTATION, WIDE BLADES
($C_{p_{t.o.}}$ = .106)
C_s = 3.5
V_c = 200 MPH
300 MPH
M_{tip} = 0.80
400 MPH
PROPELLER DIAMETER ~ FEET
T.O. POWER PER NACELLE ~ 1000 BHP
CRUISE POWER PER NACELLE ~ 1000 BHP

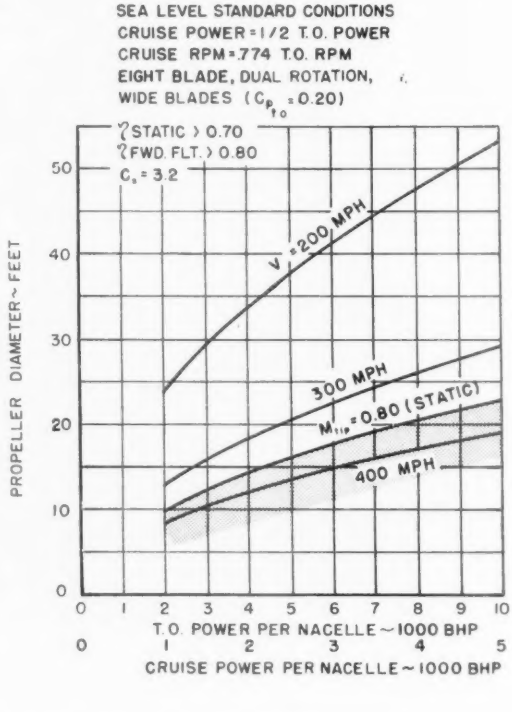

SEA LEVEL STANDARD CONDITIONS
CRUISE POWER = 1/2 T.O. POWER
CRUISE RPM = .774 T.O. RPM
EIGHT BLADE, DUAL ROTATION,
WIDE BLADES ($C_{p_{t.o.}}$ = 0.20)
η STATIC > 0.70
η FWD. FLT. > 0.80
C_s = 3.2
V_c = 200 MPH
300 MPH
M_{tip} = 0.80 (STATIC)
400 MPH
PROPELLER DIAMETER ~ FEET
T.O. POWER PER NACELLE ~ 1000 BHP
CRUISE POWER PER NACELLE ~ 1000 BHP

FIG. 1 (*top left*). FIG. 2 (*top right*). FIG. 3 (*lower left*). FIG. 4 (*lower right*).

cruise and take-off condition he wishes, insofar as power and r.p.m. are concerned, and assign values to K_1 and K_2 accordingly.

For convenience, Eq. (3) can be substituted for n_c in Eq. (5), resulting in,

$$D = \frac{BHP_c^{1/2}(550)^{1/2}K_1^{3/5}C_S^{3/2}}{\rho_{T.O.}^{1/5}\rho_c^{3/10}C_{PT.O.}^{1/5}K_2^{1/5}V_c^{3/2}} \qquad (6)$$

Propeller tip Mach Number is a limitation (and for reasonable K_1 values will be a maximum for the take-off condition) wherein the following useful expression can be derived by combining Eqs. (3) and (5):

$$M_t = \frac{n_c D}{357} = \frac{V_c^2 K_1^{3/5}(\rho_c/\rho_{T.O.})^{1/5}}{C_S C_{PT.O.}^{1/5} K_2^{1/5}(357)} \qquad (7)$$

Examination of one engine manufacturer's data on a free turbine engine reveals that $K_1^{3/5}/K_2^{1/5}$ remains approximately 1.0 regardless of the value assigned to ratio of cruise power to take-off power (K_2). This indicates that, at least for this particular power-r.p.m. relationship, the propeller diameter for high static and forward flight efficiency is relatively insensitive to reduced power operation for cruise.

Results

Curves of propeller diameter for high static and forward flight efficiency versus cruise power can now be developed from Eqs. (6) and (7) for various ambient conditions, cruise - take-off power and r.p.m. relationships, propeller configurations, and desired level of static and forward flight efficiencies. For example, if the following values are used:

Propeller configuration: three blades, single rotation, wide blades

$C_{PT.O.}$ = 0.07 (reference 2, Figs. 27 and 28c)
C_S = 4.0 (reference 1, Fig. 12) for η = 0.83
K_1 = 0.774 for T-53 for K_2 = 0.5
K_2 = 0.5
$\rho_{T.O.}$ = ρ_c = 0.002378 for sea-level operation

The curves of Fig. 1 result. Fig. 2 extends the data to higher powers. Fig. 3 presents the data for the four-blade, single-rotation and the six-blade, dual-rotation configurations. Fig. 4 presents the data for the eight-blade, dual-rotation configuration.

Other curves for other propeller configurations, etc., could be developed by using the proper values in Eqs. (6) and (7).

Discussion

The curves presented herein are useful in the preliminary design of a new VTOL aircraft by quickly establishing the boundary conditions in which efficient operation both statically and in forward flight can be obtained. For example, suppose that it is desired to use (a) the YT-53-L-1 gas-turbine engine (see Lycoming Spec. 104.9) having 825 s.hp. for take-off, (b) a three-blade (wide blade), single-rotation propeller, (c) cruise power of 1/2 take-off power, and (d) sea-level ambient conditions. From Fig. 1 at a cruise power of 412 b.hp., a propeller diameter of 10.7 ft. corresponds to an M_t of 0.80 and a forward flight speed in cruise of 360 m.p.h. If a lower cruise speed results from the airplane drag characteristics, then a still higher propeller diameter can be used, which would improve the static thrust since it can be shown that static thrust = 10.42 [(Fig. of merit) (D) $(BHP)\sigma^{1/2}]^{2/3}$. If a smaller diameter is desired, then it is desirable to increase the solidity because operation below the M_t = 0.80 line would involve increasing r.p.m. This r.p.m. increase, at constant forward speed, results in a lower C_S value, which beneficially results in slightly higher forward flight propulsive efficiency, but, in spite of this increase, the reduced D results in a higher $C_{PT.O.}$ This higher $C_{PT.O.}$ would be accompanied by a decrease in the figure of merit for static operation if higher solidity were not used.

Conclusion

Basic equations are presented from which curves can be drawn for particular propeller configurations and operating conditions, wherein propeller diameters for both high static and forward flight propulsive efficiency can be obtained. Representative curves are presented for one set of conditions for various propeller configurations. It is believed that the use of these expressions and curves will facilitate propeller selection for VTOL aircraft.

References

[1] Biermann, David, and Gray, W. H., *Wind-Tunnel Tests of Single and Dual-Rotating Tractor Propellers of Large Blade Width*, NACA ARR 520, September, 1942.

[2] Gilman, Jean, *Static Thrust and Torque Characteristics of Single and Dual Rotating Tractor Propellers*, NACA Memo, Report L-750, June, 1944.

▲ ▲ ▲

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Thrust-Reverser Devices

Several types of thrust-reverser devices are equally satisfactory in reversing or modulating the engine thrust; therefore, other considerations, such as the inherent fail-safe characteristics, ease and convenience of installation, weight and performance penalty to the aircraft, actuation power requirements, compatibility with silencer nozzles and other components of the exhaust system, must serve as the basis for selecting the most suitable device. The functional practicability of a thrust-reverser installation has been demonstrated on the Allison J-71 engine.

Thrust-Reverser Effectiveness

It is by now well recognized that reversal of the engine thrust is not only one of the most effective but possibly one of the most practical means of decelerating jet aircraft. The effectiveness of thrust reversal in braking the ground roll after touchdown has been demonstrated in a most convincing manner. For instance, the French Air Force de Havilland Vampire aircraft, equipped with the SNECMA (Société Nationale d'Étude et de Construction de Moteurs d'Aviation, Paris, France) thrust-reverser device, proved capable of stopping on a dry runway, by using both the thrust reverser and the wheel brakes, within a ground-roll distance that was approximately 60 per cent of the distance when using wheel brakes alone. Without applying the wheel brakes—i.e., simulating landing on an icy runway—the thrust reverser proved capable of bringing the aircraft to a complete stop within a ground-roll distance shorter, or at least not greater, than that required for stopping on a dry runway with the wheel brakes alone. The demonstrations with this aircraft during the Air Show of 1953 at the Paris-LeBourget Airport were, according to the technical writers reporting this performance, one of the main attractions. It is of interest to note that a reduction in landing distance of the same order as demonstrated by the Vampire is also predicted for practically every other type of jet aircraft, single- and multiengined alike, regardless of whether the particular airplane under consideration is designed for flight at subsonic or supersonic speeds.[1–5]

The Wright Air Development Center and NACA carried out and sponsored a number of feasibility investigations consisting of thrust-reverser performance analysis, design studies, and testing of both small-scale models and full-scale experimental hardware. These programs yielded encouraging results, indicating that there are several possible types of device capable of adequate thrust reversal[4] and that application of a suitable device to a particular aircraft would be feasible and practical inasmuch as it would not penalize either the aircraft or its performance.[5] One of the milestones in these investigations was the feasibility evaluation of a full-scale, experimental, prototype thrust-reverser device on an F-84F aircraft. The thrust reverser used for this purpose employed the same principle as utilized by SNECMA in France and was designed and built at the Wright Air Development Center. The effectiveness of the reverser installation in decelerating the aircraft during landing and also in flight was again verified.

The effectiveness of thrust-reverser devices in decelerating aircraft provides—in addition to the reduction in landing ground-roll distance even on icy or slippery runways—other advantages which, though perhaps obvious, are worthy of brief mention here. Aircraft equipped with wheel brakes and a thrust reverser have two methods for stopping; consequently, the reverser increases safety during landing, providing a safety factor equal to or greater than that achieved on airplanes having reversible-pitch propellers. With thrust reversers just as with reversible-pitch propellers, there is a reduction in wear on wheel-brake components and tires since the use of such devices achieves a significant decrease in the amount of energy which has to be dissipated before the aircraft is slowed down to taxiing speed or is brought to a complete stop.

Because of certain operational peculiarities of turbojet engines and the typical features of jet aircraft—such as relatively slow response to changes in engine-power setting and high wing loadings accompanied by high speeds during flight and landing—the thrust reverser

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can increase the efficiency of operation of jet aircraft more significantly than the reversible-pitch propeller on the propeller-driven airplane. Thrust reversers can be utilized on the ground or in flight not only for reversing but also to reduce or annul the effective thrust acting on the aircraft and to permit such "modulation of thrust" without requiring a change in engine throttle. Thus, these devices can eliminate the necessity of reducing engine speed during landing approach. The pilot is able to decrease the propulsive thrust in any desired manner, continuously or in successive steps, without reducing the power setting of the engine which can continue to operate at a high r.p.m. (about normal rated power, for instance) even during the final approach. By employing such a technique, maximum take-off thrust can be regained practically instantaneously if the landing cannot be accomplished at the first attempt or in case of a "wave-off." Without the use of the thrust-reverser device, this is not feasible since, once the speed of a turbojet engine has been reduced to any significant extent, several seconds are required to regain maximum power output.

Another important consideration with respect to the use of thrust-reverser devices is that, during thrust reversal, the net reversed thrust on the aircraft is the sum of the reverse portion of engine gross thrust and of ram drag.[5] With the latter as an additive term, the maximum net reverse thrust obtainable in flight exceeds that which can be obtained statically, and it may become larger than the forward propelling thrust at the same engine-power setting if the flight speed is sufficiently high. Consequently, thrust-reverser devices can also be effective in reducing flight speed and, therefore, can substantially reduce, and in many cases eliminate, the need for conventional dive brakes.[4] As an example, the deceleration of an airplane of 20,000 lbs. weight, equipped with an engine of 10,000 lbs. rated static thrust, shall be considered. Such aircraft, during level flight at 25,000 ft., could be decelerated with a suitable thrust-reverser device from an initial flight speed of Mach 1.0 before braking to a terminal flight speed of Mach 0.8 after braking in almost half the time required when using dive brakes of 10-sq.ft. effective area, even when assuming that the power of the engine is reduced to 30 per cent of the rated value while the dive brakes are extended. Using a thrust-reverser device instead of dive brakes, the pilot does not have to throttle the engine to some minimum allowable r.p.m. in order to obtain maximum braking; also, the time span necessary for speeding up the engine after deceleration will be eliminated because the engine would continue to operate at maximum r.p.m. during thrust reversal.

Types of Thrust-Reverser Device

Many different devices have been proposed to accomplish reversal of the engine thrust; however, with respect to principles of operation, each of them falls into one of two categories—namely, bucket thrust reversers and turning-vane ring-cascade devices.

For obtaining reverse thrust with bucket-type reversers, a bucket, in principle similar to those used on Pelton turbine wheels, is placed into the exhaust stream. This device is often referred to as a "target," and hence the designation target-type thrust reverser. The bucket is shaped to serve two purposes—to block the exhaust flow and to reverse its direction by vectoring it forward. The principle of these devices is illustrated by the schematic diagrams in Fig. 1. As can be seen, the bucket proper, used as a target, can be located either aft or forward of the tailpipe exit and is placed into the jet only when the thrust reverser is in use; at any other time, it is retracted so as to clear the passage of the exhaust flow. There have been many different shapes proposed for the bucket, such as a cone, half-cylinder, hemisphere, "V" and "W" gutters, etc., and it is conceivable that in some cases the surfaces forming the bucket could be designed so that when retracted—i.e., in the forward-thrust position—they could serve as a part of the aft nacelle fairing or ejector body or even as a portion of the tailpipe wall.

The designation of turning-vane ring-cascade reversers refers to devices in which the direction of the exhaust jet is reversed while passing through channels between a series of turning-vane rings linked together to form a cylindrical or conical cascade. The operating principles of various devices employing such a turning-vane cascade differ mainly in the means utilized to cause the exhaust flow to pass through the reversing channels. In the thrust reverser originated by SNECMA, the exhaust jet is deflected onto the turning vanes. As indicated by the schematic diagrams in Fig. 2, either obstructing flaps or high-pressure, engine bleed-air jets can be employed as the means for primary deflection, which is accomplished by a partial blockage of the exhaust passage. On the other hand, the exhaust flow can also be forced to pass through the turning-vanes by closing off completely its passage at the aft end of the turning-vane cascade, as illustrated by the schematic diagrams in Fig. 3. Spreading of the exhaust jet under the effect of centrifugal force is a third possible means of causing the gas flow to pass through the reversing channels formed by the turning-vane cascade. This can be achieved, as proposed by Professor Ackeret of the Swiss Federal Institute of Technology, Zurich, by placing a number of blades shaped as symmetrical airfoils forward of the tailpipe nozzle exit (see Fig. 4). To obtain reverse thrust, these blades are rotated and cause spinning of the exhaust flow within the tailpipe, which, upon leaving the tailpipe, spreads outward under the effect of centrifugal force and is caught and reversed by the turning vanes. When the airfoil blades within the tailpipe are set in the direction of flow and thus are not imparting rotational movement to the gas stream, the exhaust jet emerges straight from the pipe without being affected by the turning-vane ring cascade.[1]

Depending upon the means used to cause the exhaust jet to pass through the reversing channels, the turning-vane ring-cascade device can be located either forward

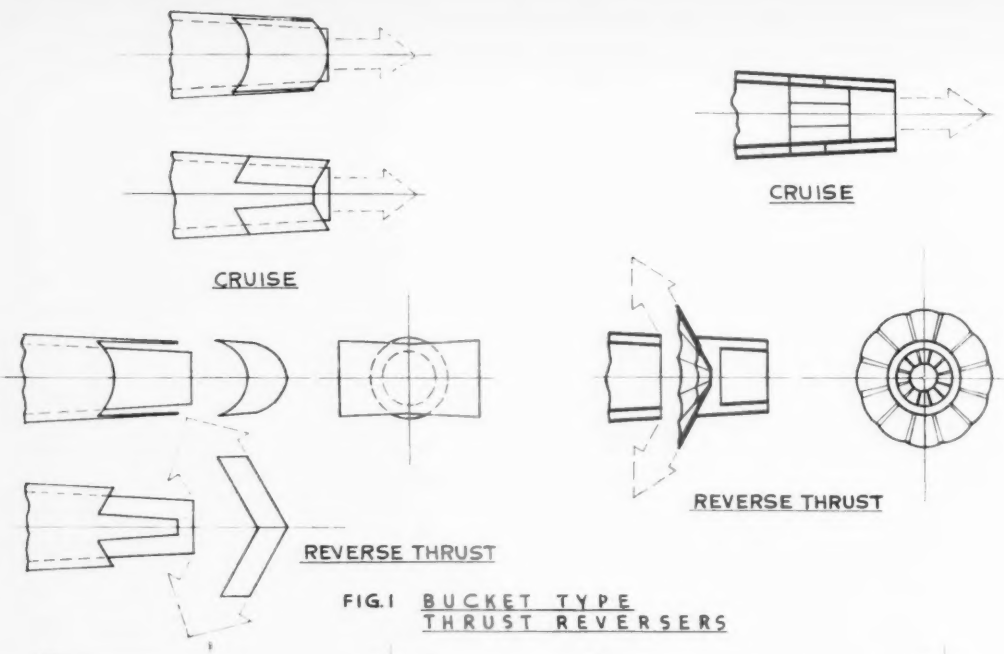

FIG. 1 BUCKET TYPE THRUST REVERSERS

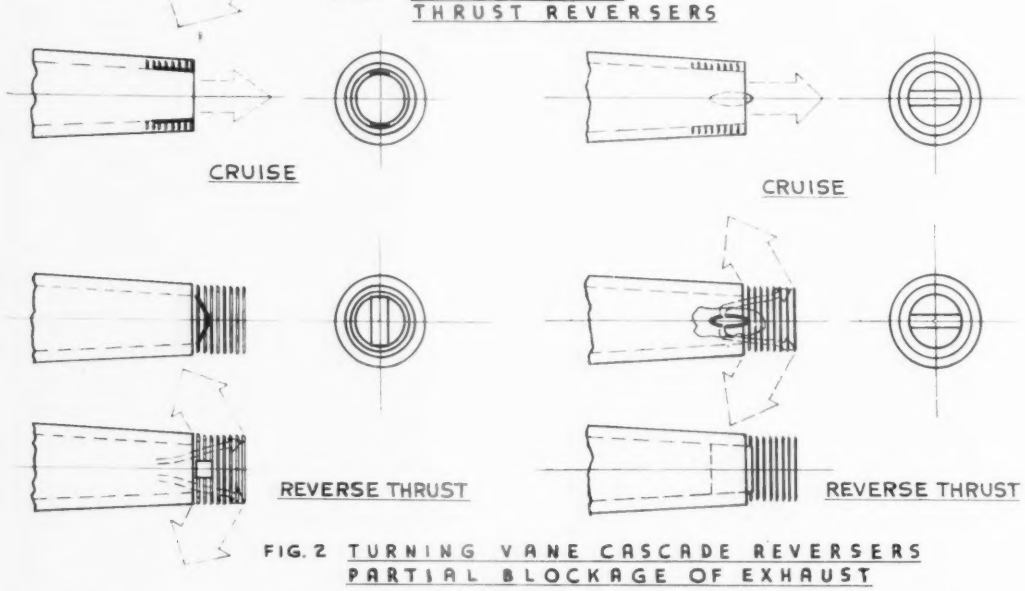

FIG. 2 TURNING VANE CASCADE REVERSERS PARTIAL BLOCKAGE OF EXHAUST

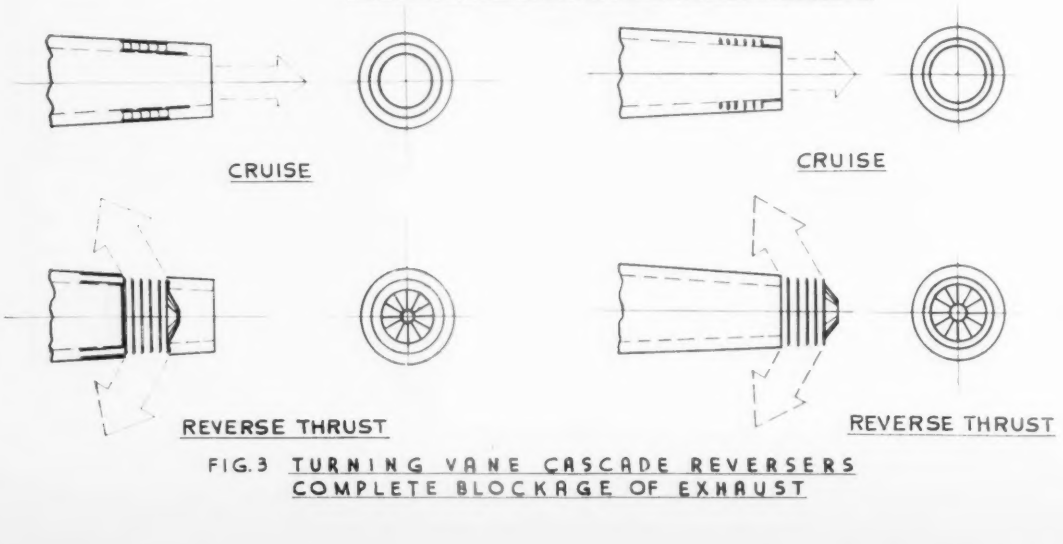

FIG. 3 TURNING VANE CASCADE REVERSERS COMPLETE BLOCKAGE OF EXHAUST

or aft of the nozzle exit. The turning vanes can be either symmetrical or asymmetrical with respect to their entrance and exit angles; their shape can be thin of single curvature or thick of double curvature, and the reversing channels formed by them can be either the "impulse" or the "reaction" type, depending upon the location of the minimum cross-sectional area within the channel.

Concerning the capability of reversing or modulating the engine thrust without requiring a change in throttle setting, practically all of the devices proposed and investigated to date appear to be equally satisfactory. Therefore, the selection of a particular device has to be made on the basis of other considerations such as the inherent fail-safe characteristics, ease and convenience of installation, weight and performance penalty to the aircraft, actuation power requirements, etc. The compatibility of thrust-reverser devices with variable-area exit nozzles, afterburning tailpipes, cooling-air and/or thrust augmentation ejector configurations, jet noise-attenuating nozzles, etc., has to be determined. Although there are several thrust-reverser configurations which can be applied to engines equipped with afterburners, because of the limitations in currently available materials, they cannot be used either for reversing or reducing the thrust when the afterburner is operating since they all necessitate direct impingement of the exhaust on some portion of their working surfaces, which would cause excessive heating during the reheat cycle.

Fail-Safe Requirements

Consideration of the fail-safe features of thrust-reverser devices has to include both the cockpit controls and the thrust reverser itself. One of the most obvious fail-safe requirements is that the inadvertent reversal of the engine thrust has to be prevented under all circumstances. Consequently, the cockpit controls have to be designed so as to comply with this imperative requirement. Also, it seems desirable to integrate the thrust-reverser control with that of the engine power in a manner similar to that employed with reversible-pitch propellers. While this can be accomplished quite easily on nonafterburning engines, it appears that on afterburning engines the thrust-reverser controls in the cockpit have to be separated from the engine-power lever.

At present, there appear to be two schools of thought with regard to the fail-safe features of the thrust reverser. One concept requires that it be impossible to cause the device to move into the thrust-reducing or reversing position, or to remain in such a position, without applying actuation power. The other proposes that, in case of actuation-power failure, the device shall remain either in the forward or in the reverse-thrust position, depending upon the cockpit signal received prior to the malfunction. The first of these two fail-safe requirements applies to devices which are also intended for use during flight. Compliance with this requirement will prevent the device from becoming locked in the reverse-thrust position because of failure in actuation power, which is imperative during flight. The advantage of a design based on this particular fail-safe concept is that, should actuation power failure occur after the device has been extended to the thrust-reducing or thrust-reversing position, the resulting effect would cease and the device would return to the forward-thrust position. Conversely, the disadvantage is that failure in actuation power would cause, regardless of the instance of its occurrence, a cessation of the thrust-reversing or reducing action.

Since the other fail-safe concept requires that the actuated device remain in the reverse-thrust position even with actuation power malfunction, it can only be applied to devices used for slowing down aircraft on the ground, either during landing after touchdown or in case of a refused take-off. Compliance with this requirement has the advantage that, once the device has been actuated, thrust-reversing action is ensured even with a failure in actuation power.

Weight

A comparison of the weight of the working surfaces proper—i.e., considering only the weight of components in the thrust reverser and outside the actuation system, excluding any structures, actuation, and control mechanisms, etc.—of the various thrust-reverser configurations briefly described above leads to the conclusion that the turning-vane ring-cascade devices which require the least amount of obstruction in the exhaust passage are the lightest ones. On the other hand, these devices require that, during thrust reversal or reduction, the turning-vane cascade be located aft of the tailpipe nozzle exit and, therefore, be made retractable in order to eliminate an increase in airplane drag during normal forward flight. Depending upon the aft nacelle configuration, stowage of the turning-vane cascade in the retracted position—i.e., for forward

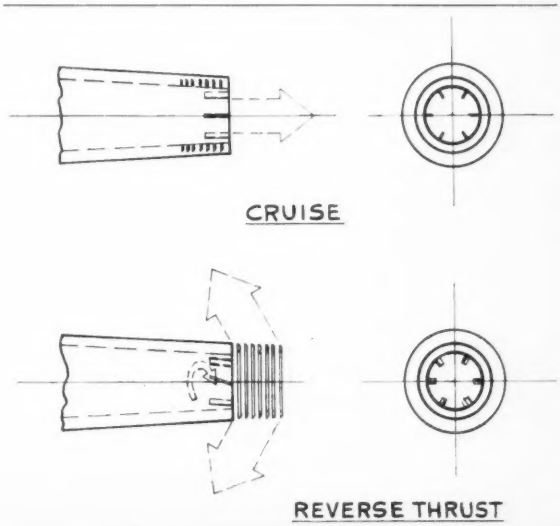

FIG. 4. Reverser with swirl blades.

thrust—may necessitate an increase in the diameter of the aft nacelle fairing and/or in its boat-tail angle, or in the relatively long extension-retraction stroke of the vane cascade, which in turn results in increased actuation power requirements. Also, in some cases there may be insufficient ground clearance, with the aircraft in the landing or taxiing attitude, to accommodate the turning-vane cascade in the extended position.

Turning-vane ring-cascade reversers with a complete blockage of the exhaust jet passage are significantly heavier than the ones requiring only a partial obstruction of the exhaust-gas flow path. The advantage of these devices, which in some cases may offset the disadvantage of their greater weight, lies in the fact that the turning-vane cascade does not necessarily have to be extended aft of the nozzle exit and can be located forward of the tailpipe exit during both thrust reversal and normal cruise; at such a location there is, as a rule, sufficient clearance between the nacelle skin and the tailpipe proper to stow the turning-vane cascade without necessitating an increase in aft nacelle diameters or boat-tail angle. In addition, with such configurations the actuation power requirements are generally less than with turning-vane cascades necessitating a long extension-retraction stroke. On the other hand, these devices require vents in the skin of both the tailpipe and the surrounding nacelle fairing to provide for exhaust-gas exit ports during thrust reversing or modulating action. During normal forward flight, the vents serving as reverse gas-exit ports have to be sealed off to prevent thrust loss from exhaust-gas leakage and pressurization and contamination of the nacelle by hot exhaust. It is found that sealing off such reverse gas-exit ports in the tailpipe may represent a rather formidable problem; it definitely results in an increase in the weight of the tailpipe and, therefore, in that of the entire installation.

Bucket-type thrust reversers are generally heavy; their installed weight is approximately the same as that of turning-vane ring-cascade devices which have a complete closure of the exhaust-gas passage. It appears that such bucket-type thrust reversers may be less advantageous because, in addition to their relatively large weight, they produce the most diffused and least controllable reverse gas-flow pattern and are, therefore, more likely to cause undesired impingement of hot gases on adjacent structures, attachment of reverse gas flow to the aft nacelle fairing, and, consequently, reingestion of the reversed exhaust flow.

Thrust-Reverser Actuation Systems

The first thrust-reverser installations which became operational, developed by SNECMA for the French Air Force, utilized an electromechanical actuation system consisting of electric motors driving jackscrews through a suitable arrangement of reduction gears, angle gears, and torsion drives. This equipment is relatively heavy because of the weight of the electric motors, and the drives have to be located so as not to be subjected to soaking temperatures in excess of 250°F. Hydraulic actuation systems, utilizing either aircraft hydraulic oil (for instance, in accordance with Specification MIL-0-5606) or aircraft gas-turbine lubricating oil (for instance, in accordance with Specification MIL-L-7808), with a pressure of 1,500 or 3,000 psi, are superior to electromechanical systems because of less weight. In addition, hydraulic actuation systems have the advantage that their components can be made available without requiring extensive development and that such systems are well suited for accomplishing thrust modulation. However, because of the temperature limitations inherent in both hydraulic and lubricating oils presently obtainable, components containing such fluids must be located where the environmental temperature is compatible with their characteristics, or provisions must be made to prevent these oils from attaining excessive temperatures. Furthermore, the use of hydraulic fluids within the engine nacelle augments the fire danger in case of spillage on hot components due to leakage or line breakage. One of the most desirable actuation systems operates with high-pressure engine bleed air. Bleed air from the compressor can be utilized for thrust-reverser actuation either by means of pneumatic power cylinders or a rotating prime mover, such as a positive-displacement motor or a turbine driving jackscrews. Such systems have two major advantages—namely, there is satisfactory operation at environmental temperatures which are significantly higher than those permitted with electric motors or hydraulic and lubricating oils, and there is no potential fire hazard. A disadvantage results from the relatively low pressure at which the bleed air is available in current turbojet engines (250 psia or lower at maximum engine power and 15 to 30 psia at idle).

The AeroBRAKE Thrust Reverser

The development of an AeroBRAKE thrust reverser for the Allison J-71 engine has recently been completed. The main purpose of this particular installation, as developed by Aerojet-General Corporation for Allison Division of General Motors Corporation, was to demonstrate the practicability of an engine-mounted thrust-reverser device, suitable for application with a variable-area primary jet nozzle, and with a tailpipe capable of accepting a take-off afterburner equipped with a variable-area afterburner cooling-air ejector, and which is capable of continuous modulation of the thrust without changing the engine power setting. The thrust reverser is of the turning-vane cascade type with partial blockage of the exhaust—i.e., utilizing the principle originally evolved by SNECMA. The program included a total of 170 hours of testing on the engine and culminated in a performance calibration test, at various engine operating conditions, of approximately 30 hours' duration. The program was successfully completed. It was established that integration of the thrust reverser with the engine exhaust system was satisfactory; the AeroBRAKE proved to be capable of effective thrust reversal without any adverse effects on

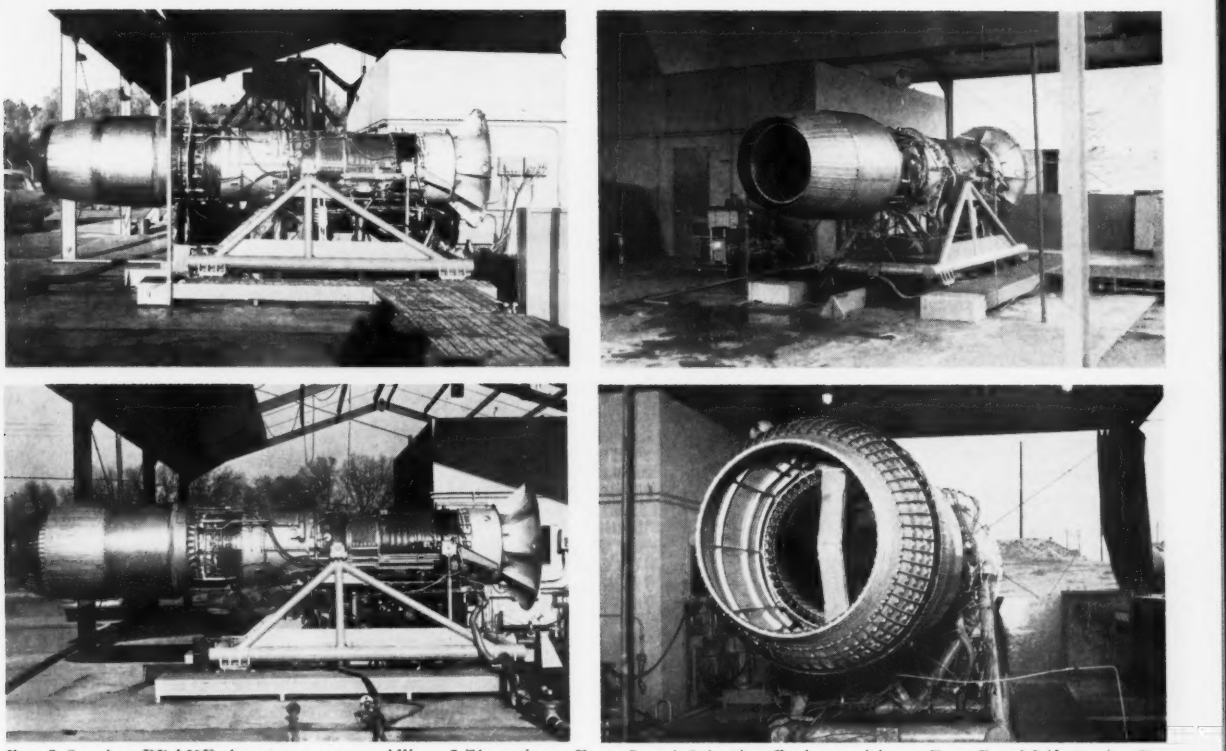

FIG. 5–8. AeroBRAKE thrust reverser on Allison J-71 engine. FIGS. 5 and 6 (*top*). Cruise position. FIGS. 7 and 8 (*bottom*). Reverse-thrust position.

the performance of the engine and can be used efficiently without detriment to the operation of the variable-area exhaust nozzle or the ejector of variable exit diameter. This fail-safe reverser is also for use in flight and has a hydraulic actuation system; and, when fast action is desired, maximum reverse thrust can be obtained within approximately 3.5 sec. Furthermore, it provides control of the effective thrust in any desired manner, whether in the forward propelling direction or in the reversing range, even with the engine operating at the maximum rated r.p.m.

This AeroBRAKE thrust-reverser installation was tested on an open-air turbojet-engine testing facility at Aerojet's Sacramento plant. The AeroBRAKE is shown in the retracted position—i.e., for forward thrust—in Figs. 5 and 6. The full reverse-thrust position is shown in Figs. 7 and 8. In order to accomplish the desired integration with the engine exhaust, all structures and working surfaces of the thrust reverser proper were assembled within and attached to a single unison cage structure, which is sandwiched into the annular space between the tailpipe and afterburner cooling-air ejector shroud. This shroud, with the ejector leaves forming the variable-area secondary nozzle, serves also as the aft nacelle fairing. Not only is the thrust reverser a portion of the exhaust-system structure, but it is also utilized to accomplish modulation of the ejector exit diameter as a function of the primary jet-exit nozzle area. For this purpose, the ejector leaves, which are hinged to the outer shroud which surrounds the entire installation, are also attached to the cams on the AeroBRAKE cage assembly. The instantaneous setting of the primary-jet nozzle segments is fed back through a suitable mechanical linkage to the thrust-reverser actuation system, which in turn positions the AeroBRAKE cage assembly so that the cooling-air-ejector exit diameter attains the size required to pump cooling air at the required rate. The hydraulic actuator and servovalve, which operate with hydraulic oil (Specification MIL-O-5606) at 3,000 psi, are mounted on the compressor housing to avoid excessive environmental temperatures. The actuation forces are transmitted to the components by means of compression-tension linear drives, which meet the requirements of Specification MIL-C-5503 and operate without lubricants.

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The problems which arise in engineering large and complex systems require solutions if technical resources are to remain adequate to meet demands on our technology. Some possible solutions to the multidiscipline, communication, and coordination problems are suggested.

How to Improve Systems Engineering

John N. Warfield,* University of Illinois

Introduction

The task of engineering complex systems is a distinguishing feature of technical activity of the past 25 years. It is not uncommon to see system development projects under way which involve the need to apply almost every technical principle known to physics and chemistry and indeed sometimes involve the need for new principles yet awaiting discovery.

It seems likely that in the next hundred years almost every industrial process which can be reduced to a set of sequences of logical steps will be done automatically if economic and technical limitations can be overcome.

The advent of systems involving millions of components such as the larger high-speed computing machines and the requirement for systems of which such computing machines are merely a part has created a technical employment atmosphere where often one man can contribute only a small fraction of the total effort required. At the same time the complexity and significance—not to mention the cost—of the decisions to be made have destroyed any tendency to base such decisions on prejudices or limited experience and have stimulated the application of the scientific method (which, after all, is essentially applied logic) to heretofore unknown limits.

A problem of intercommunication has developed out of the need to keep each engineer informed of his particular task in system development and of the surrounding facts which usually he must evaluate in terms of both his task and the overall system performance.

When systems development is distributed not only among many men but also among several geographical locations, the problem of coordination, challenging enough (to say the least) when the activity is localized, becomes even more demanding.

There is a need to consider the systems engineering problem in its own right and to inquire whether means exist for improving systems engineering practices, especially in view of the problem of potential saturation of technical resources which it now seems clear may not be compatible with demands on the technology. In short, is it possible to make more efficient use of engineering talent in systems engineering? Even if the percentage improvement in systems engineering practice is relatively small, the gains to be realized may be quite significant.

Problems to Be Solved

Three problems seem to be worth considering in view of their apparent significance in systems engineering. These problems are the multidiscipline problem, the communication problem, and the coordination problem.

The multidiscipline problem arises whenever a system development involves a need for technical information and experience in numerous areas of knowledge or disciplines and a decision based on such is required. The implications of this problem and evidences of its importance extend deeper into our technical society than might at first be conceived. It is felt, for example, that the actions of certain engineering colleges in eliminating traditional areas of instruction in favor of a more general and more mathematical education is a direct consequence of this multidiscipline problem.

Is there any action which can be taken to improve the situation? An ideal solution would clearly be to have technical personnel with both broad and deep education in numerous disciplines as well as extensive experience. In the ideal solution lies the key to possible improvement. The first point is that conventional educational procedures are not adequate to produce the relatively limited number of persons to fill the need. The best proof of this is the existence of the problem. A 4-year program cannot produce the type of people who are needed. Instead, perhaps a 7-year program designed not to produce specialists in an area but instead a person equipped to work competently in various disciplines is a partial answer. Similarities between apparently unrelated disciplines would be emphasized, the language of mathematics would be

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applied universally, and improved laboratory work would be essential. Those who disclaim the practicality of this approach had best compare the attendant problems with those which will be faced by future engineers who will be called upon to push engineering system developments to the limit of resolution.

The communication problem is visualized as the task of enabling all who are engaged in a systems effort to become cognizant of the essential information and to maintain this cognizance as system development, test, and application take place. The most essential requirement to improve this phase of systems engineering is the development of universal methods of communication. The functional block-diagram approach to presentation in which the essential system logic is exhibited seems to be the most effective medium, but it must be supplemented by detail block diagrams showing how the functional requirements of a system are to be met by engineering devices. The importance of so-called advanced mathematics as a communication tool has not been stressed. The ability to describe a system essentially in the language of the theory of point sets needs to be fostered, for example. Technical articles on system development must be written and edited more carefully than at present, and the essential content must be displayed more clearly. Each of these points can be implemented by a carefully planned company training program. Those limited programs which now exist should be supplemented ten times over with training in communication skills.

The coordination problem is actually the focal point of the two problems just discussed. Coordination not only involves assuring that system development proceeds smoothly but also decisions of the multidiscipline character. If the foregoing problems are attacked, coordination should become easier. It should be recognized that many aspects of coordination can, in effect, be automatized. The same principles which are used in logical design of digital computers can be applied to organizational aspects of coordination. Again, company training programs in elementary mathematical logic and statistical decision theory can bring benefits to those who have complex problems of coordination.

Coordination can proceed most effectively only if there is widespread understanding of the logical structure of the system problem.

Conclusion

In the projected improvements in systems engineering, a new kind of education is proposed designed to produce persons with competence in a number of scientific disciplines. Methods for improving communication have been suggested, including the universal application of functional and detail block diagrams, increased and more effective use of mathematics as a language, and increased attention to the editing and summarizing of technical articles, with company training programs designed to promote these ends.

The problem of effective coordination of complex system developments can be attacked by improving communication and employing persons who are better equipped to work in multiple areas. Many aspects of coordination are identical to the technical problem of logical design of digital computers, hence training in the methods of mathematical logic applied to system design should increase substantially the efficiency of the coordinator.

Systems engineering hinges on seven basic steps: (1) task definition, (2) development of alternative approaches, (3) development based on the best alternative, (4) optimizing by weighting procedures, (5) organization of test and maintenance procedures in parallel with system development, (6) pinpointing essential research and carrying it out, and (7) planned cross checks and independent monitoring of system development activity.

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Two figures of merit are developed which justify establishing a minimum spring rate for the gyroscope structure and its mounting bracket.

Rigidity as a Factor in Rate Gyro Mounting

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Introduction

A successful weight reduction program, whether in design of an air frame or in design of components which will be installed in one, demands that there be valid engineering justification for all weight expended in increasing structural rigidity. It is the purpose of this paper to demonstrate that structural compliances reduce the natural frequency of a rate sensing gyroscope. The two figures of merit to be developed will provide justification for establishing a minimum spring rate for the gyroscope structure and for its mounting bracket.

The air-frame stress analyst to whose attention this paper is largely directed cannot be expected to be familiar with the details of a rate gyroscope; thus some explanation of its operation is in order.

The Rate Gyroscope

A rate gyroscope is an electric motor so mounted that its case can rotate about an axis perpendicular to its shaft. The spin axis of the rotor is termed the spin reference axis, while the axis about which the case is free to rotate is termed the output axis. These

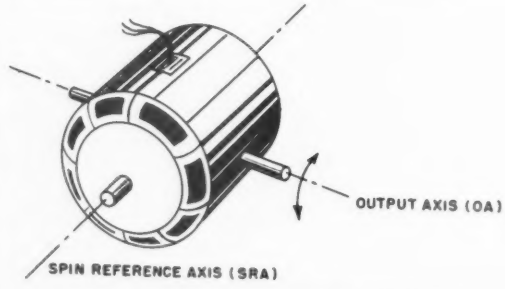

Fig. 1. Single degree of freedom gyroscope.

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axes are indicated in Fig. 1; a third axis, the input axis, is indicated in Fig. 2.

The basic phenomenon which makes it possible to use the gyroscope as an angular velocity or "rate" measuring instrument is that, if an angular rate $\dot{\Phi}$ of Fig. 2 is applied around the instrument's input axis, a torque T_{refl} will appear around its output axis. If a means of measuring this output axis torque can be provided, its value can be used as a measure of the magnitude of the input rate which produced it.

The relationship between the input rate $\dot{\Phi}$, the output torque T_{refl}, and the angular momentum H of the

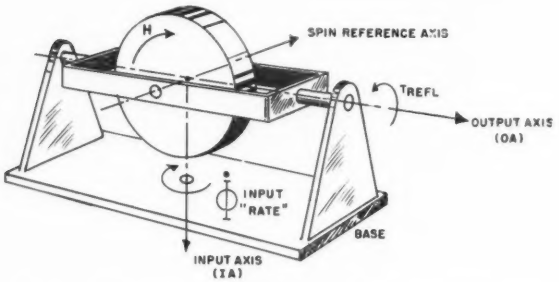

FIG. 2. Input rate applied to a single degree of freedom gyro.

rotor is

$$T_{refl} = H\dot{\Phi} \tag{1}$$

where the torque is in dyne cm. if the angular momentum is stated in gm. cm.^{2} rad./sec., and the input rate is stated in rad./sec.

The torque produced by the input rate is measured by opposing it with the torque produced by a set of rate springs connected between the rotor mounting frame of the gimbal and the base of the instrument. The input-rate-produced torque then deflects the gimbal away from its rest position until it is in equilibrium with the torque produced by the springs. Thus, if T_S, the torque produced by deflection of the rate springs, is

$$T_S = K_{OA}\theta_{OA} \tag{2}$$

and, if at equilibrium,

$$T_{refl} = T_S \tag{3}$$

substitution of Eqs. (1) and (2) in Eq. (3) gives

$$H\dot{\Phi} = K_{OA}\theta_{OA} \tag{4}$$

where K_{OA} is the output axis spring rate and θ_{OA} is the angular deflection of the gimbal from its rest position. These quantities and the arrangement of the rate springs are indicated schematically in Fig. 3.

Solving Eq. (4) for Φ produces

$$\Phi = (K_{OA}/H)\theta_{OA} \tag{5}$$

In this equation, K_{OA} and H may be assumed constant; thus the magnitude of θ_{OA}, the output axis deflection angle, may be used as a measure of Φ, the output axis angular velocity. This output axis deflection angle is converted into an electrical signal by a potentiometer or an inductive pickoff.

Rate Gyroscope Natural Frequency, Rotor Static Condition

Ideally, the moment of inertia of the rotor and its gimbal around axes perpendicular to the spin axis would be zero. Actually, J_{OA}, the rotor and gimbal moment of inertia around the output axis, and K_{OA}, the spring rate around the output axis, form a second-order system. The natural frequency of this system is an important factor in the response of the instrument, and any factors which tend to reduce its value must be avoided.

A usually neglected compliance, shown schematically as a pair of springs allowing motion of the rotor about its input axis, has been included in Fig. 3. It is this compliance which produces the reduction in natural frequency to be considered.

Neglecting this additional compliance, the equation for such a second-order system may be written

$$J_{OA}\ddot{\theta} + C_{OA}\dot{\theta} + K_{OA}\theta = 0 \tag{6}$$

where C_{OA} is the viscous damping coefficient acting about the output axis. Natural frequency is, for this system,

$$\omega_{ns}^2 = K_{OA}/J_{OA} \tag{7}$$

The s in the subscript of this output axis natural frequency ω_{ns}, which neglects input axis compliance, is used to indicate that it applies with the rotor not rotating, or static. The figure of merit R_{gs}, which will be developed as a measure of gyroscope structural rigidity, will be the ratio of rotor running natural frequency to this rotor static natural frequency.

$$R_{gs} = \omega_{nr}/\omega_{ns} \tag{8}$$

where R_{gs} is the gyro structural figure of merit and ω_{ns} is the rotor running natural frequency. Note that, in this case and in the remainder of the paper, natural frequencies are stated in radians per second.

The figure of merit R_{gm}, which will be developed as a measure of gyroscope mounting rigidity, will also be

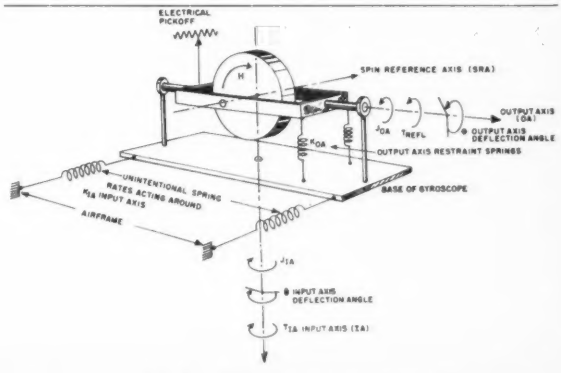

FIG. 3. Complete rate gyroscope.

a ratio of two natural frequencies—the ratio of the natural frequency of the gyro with its rotor running and mounted on the air-frame attachment fixture to the natural frequency of the gyroscope with its rotor running and with its base clamped rigidly to a massive body.

Rate Gyroscope Natural Frequency, Rotor Running Condition

If the rotor is running, the effects of the input axis compliance can no longer be neglected since this compliance allows the gyroscope to deflect about its input axis in response to the torque produced by its angular velocity around its output axis. The input axis torque T_{IA} due to the output axis rate $\dot{\theta}$ is

$$T_{IA} = H\dot{\theta} \tag{9}$$

Taking this interaction into account, two simultaneous second-order system equations similar to Eq. (6) must be written—one for torques summed around the output axis and the second for torques summed around the input axis.

$$J_{OA}\ddot{\theta} + C_{OA}\dot{\theta} + K_{OA}\theta - T = 0 \tag{10}$$

$$J_{IA}\ddot{\Phi} + C_{IA}\dot{\Phi} + K_{IA}\Phi + T_{IA} = 0 \tag{11}$$

where J_{IA} is the moment of inertia of the rotor and gimbal around the input axis and C_{IA} is the viscous damping coefficient acting around the input axis. Substitution of Eqs. (1) and (9) in Eqs. (10) and (11) produces

$$J_{OA}\ddot{\theta} + C_{OA}\dot{\theta} + K_{OA}\theta - H\dot{\Phi} = 0 \tag{12}$$

$$J_{IA}\ddot{\Phi} + C_{IA}\dot{\Phi} + K_{IA}\Phi + H\dot{\theta} = 0 \tag{13}$$

Experience indicates that, in any even remotely practical application, the torque terms $J_{IA}\ddot{\Phi}$ and $C_{IA}\dot{\Phi}$ of Eq. (13) are numerically so much smaller than the terms $K_{IA}\Phi$ and $H\dot{\theta}$ that Eq. (13) may be written

$$K_{IA}\Phi = -H\dot{\theta} \tag{14}$$

Solving Eq. (14) for Φ and differentiating so as to obtain a value of $\dot{\Phi}$ which may be substituted in Eq. (12) produces

$$\dot{\Phi} = -(H\ddot{\theta}/K_{IA}) \tag{15}$$

Performing the indicated substitution and collecting terms produces

$$[J_{OA} + (H^2/K_{IA})]\ddot{\theta} + C_{OA}\dot{\theta} + K_{OA}\theta = 0 \tag{16}$$

Eq. (16) then is the desired second-order system equation for the gyroscope output axis under the condition that the rotor is running.

From Eq. (16), a natural frequency equation similar to that of Eq. (7) may be written

$$(\omega_{nr})^2 = K_{OA}/[J_{OA} + (H^2/K_{IA})] \tag{17}$$

which applies for the rotor running condition.

Figure of Merit for the Structural Rigidity of the Gyroscope Instrument

The figure of merit R_{gs} of Eq. (8) for structural rigidity of the gyroscopic instrument itself may be written directly from Eqs. (7) and (17):

$$R_{gs} = \omega_{nrg}/\omega_{ns} = \sqrt{J_{OA}/[J_{OA} + (H^2/K_{IAg})]} \tag{18}$$

where g has been added to the subscripts for ω_{nr} and K_{IA} to indicate that these quantities are associated with the gyroscope only and not with its mounting fixtures.

Figure of Merit for the Structural Rigidity of the Air-Frame Mounting Fixture

The natural frequency of the gyroscope, measured with its base clamped rigidly to a test stand of sufficient mass so that only the instrument's own input axis compliances need be considered, obviously is the highest natural frequency which can be obtained in any application. This "gyroscope compliances only" natural frequency will thus be used as a reference natural frequency in the mounting rigidity figure of merit, just as rotor static natural frequency was used in Eq. (18) as a reference in the gyroscope rigidity figure of merit. In Eq. (20) ω_{nrm} is the rotor running natural frequency of the gyroscope, measured with the instrument mounted on the air-frame mounting fixture, and K_{IAm} is the spring rate of the air-frame mounting fixture for deflections due to a torque applied around the input axis of the gyroscope.

The total input axis spring rate for the air-frame mounted gyroscope, K_{IA}, may be written

$$1/K_{IA} = (1/K_{IAg}) + (1/K_{IAm}) \tag{19}$$

The figure of merit for the air-frame mounting fixture then will be

$$R_{gm} = \omega_{nrm}/\omega_{nrg} = \sqrt{K_{OA}K_{IAm}/[K_{OA}K_{IAm} + H^2(\omega_{nrg})^2]} \tag{20}$$

Measurement of Quantities Involved in Figures of Merit

In the gyroscope structural figure of merit, the two natural frequencies in the R_{gs} ratio are more easily measured than is K_{IA}, the spring rate around the input axis. The rotor static natural frequency ω_{ns} is determined by increasing the frequency of an oscillatory displacement applied around the gyroscope output axis until phase shift between the applied displacement and the output of the gyroscope pickoff is observed to reach 90°. The rotor rotating natural frequency ω_{nrg} is determined by applying the oscillatory displacement to the input axis. In this case, however, the rate gyroscope differentiates the forcing displacement so that a 180° phase displacement between the forcing sinusoid and the pickoff output will indicate natural frequency.

Other terms, J_{OA} and H, are determined by use of a

(*Continued on page 58*)

Using a systems analysis approach, the economic and aerodynamic factors which influence the profit-over-cost criterion are examined, and the conditions for maximizing this criterion are determined.

Aerodynamic and Economic Characteristics of Turboprop Air-Line Transport Systems

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SYMBOLS

AR	=	aspect ratio
c_a	=	air-frame cost, dollars/lb.
c_B	=	airport facility cost, dollars/lb.
C_L	=	lift coefficient
c_m	=	maintenance cost, dollars/hour/lb.
c_0	=	specific fuel consumption, lbs./b.hp./hour
c_p	=	personnel cost, dollars/flying hour
c_{pp}	=	power-plant cost, dollars/lb.
C_S	=	system cost, dollars
c_{UL}	=	useful load cost, dollars/lb.
d_{to}	=	take-off distance, ft.
f	=	cargo load factor
h	=	altitude, ft.
I_n	=	income, dollars
I_{WUL}	=	revenue, dollars/lb.
K	=	income-tax rate factor
N	=	number of airplanes in system
n	=	average number of personnel per aircraft
q	=	aerodynamic dynamic pressure, lbs./ft.^{2}
r	=	revenue rate, dollars/ton-mile
R	=	range, nautical miles (air-line operational range or distance)
t_0	=	delay time, hours
U_0	=	basic airplane utilization per year
V	=	airplane velocity, knots
V_H	=	head wind, knots
W_a	=	air-frame weight, lbs.
W_0	=	take-off weight, lbs.
Y	=	amortization period, years

INTRODUCTION

IN THE PAST, the planning of future airplanes was mainly accomplished by considering the performance characteristics and occasionally the cost of the airplane. In these times, a much broader viewpoint and refinement of analysis are now required of the planners. These are necessitated by technical advances, expansion of the transport business, and increasing competition among operators and manufacturers of transport airplanes.

With the foregoing in mind, techniques which aid in resolving the problems of the planners are indeed useful, especially if these techniques can lead to a solution in an expedient and economical way. The technique employed in this paper is a graphical method of systems analysis for turboprop transports developed in reference 1.

The systems approach for analyzing complex component interactions is becoming increasingly mandatory. It is the purpose of this paper to show the application and results of a systems analysis on turboprop transport systems. The scope of this analysis includes the airplane performance, economics of the system, and employment of the airplane. These analyses are applied to the components of the system, consisting of airplanes, personnel, useful load, airport, and equipment.

To facilitate the organization of the results and to provide a common means of assaying the many possible transport system designs, a measure of effectiveness based on the net profit over cost of the system is used.

DESCRIPTION OF THE TRANSPORT OPERATION

The daily operation of each airplane is concerned with the carrying of passengers or cargo from one initial airport to another and the return.

The hours the airplane spends in active utilization (U_0), whether in the air or on the ground being refueled, unloaded, etc., are fixed and are the same for each airairplane—i.e., 3,000 hours per year. These hours exclude the time spent in maintenance, testing, and training. To take into account the loss of active utilization in ungainful operations ("turn-around time")—such as refueling, reloading, and delays—the fixed utilization is reduced by a varying factor κ, a function of cruise speed, delay time, and range. The delay time (t_0) is arbitrarily set at 1 hour per trip in this analysis. The formula for κ is, then,

$$\kappa = 1/[1 + (Vt_0/R)]$$

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In effect, κ reduces the basic airplane yearly utilization to the true utilization.

The take-off distance, which in part determines the take-off power requirement, is set at 3,000 ft. This selection is somewhat arbitrary and subject to change according to particular specifications.

A 10 per cent reserve on fuel weight is provided. This fuel allowance is restricted for emergency reserve fuel, warmup, taxiing, etc. Since climb allowance is not computed separately in this analysis, the reserve also includes the fuel required for climb.

General Airplane Configuration

The class of airplanes developed in this analysis is the turboprop-powered transport type, with the engines conventionally attached to the wings. The landing gear is the conventional multiple-wheel cycle gear, and the tapered 2:1 ratio wing is unswept, having about a 19 per cent wing thickness ratio.

The air-frame weights are based upon an ultimate load factor of 4.5. The air-frame weight includes wings, body, tail, landing gear, standard instrumentation, insulation, fixed equipment (specialized equipment is not included), and hydraulic control equipment. The engine weight consists of the engine, propeller, nacelle, fuel system, engine controls, and accessories. The useful load is composed of passengers and/or cargo, crew, furnishings, special electronic gear, navigation and communication equipment, food, and water.

Economics of the Transport System

The economics of the system are divided into two categories for convenience—system costs and income or revenue. Cost components can be synthesized in the following manner:

$$C_S/W_0N = (c_a/V)(W_a/W_0) + (c_{pp}/V)(W_{pp}/W_0) + c_f(VU_0/R)(W_f/W_0) + c_{UL}(W_{UL}/W_0) + c_mU_0 + (c_pU_0n/W_0) + c_B$$

where

$(c_a/V)(W_a/W_0)$ = air frame
$(c_{pp}/V)(W_{pp}/W_0)$ = power plant
$c_f(VU_0/R)(W_f/W_0)$ = fuel
$c_{UL}(W_{UL}/W_0)$ = useful load
c_mU_0 = maintenance
c_pU_0n/W_0 = personnel
c_B = facility

The cost factors c_a, c_f, c_{pp}, c_m, c_B are determined on the cost per pound basis, with the exception of c_m and c_p which are determined on the basis of cost per pound per flight hour and cost per man per year, respectively. The weight ratios (W_a/W_0), (W_f/W_0), and (W_{pp}/W_0) are determined from the performance characteristics of the transport airplanes and computed by the method described in reference 1.

Income is derived from the revenue accepted for services rendered on transporting goods and/or people from one geographic point to another. The income is

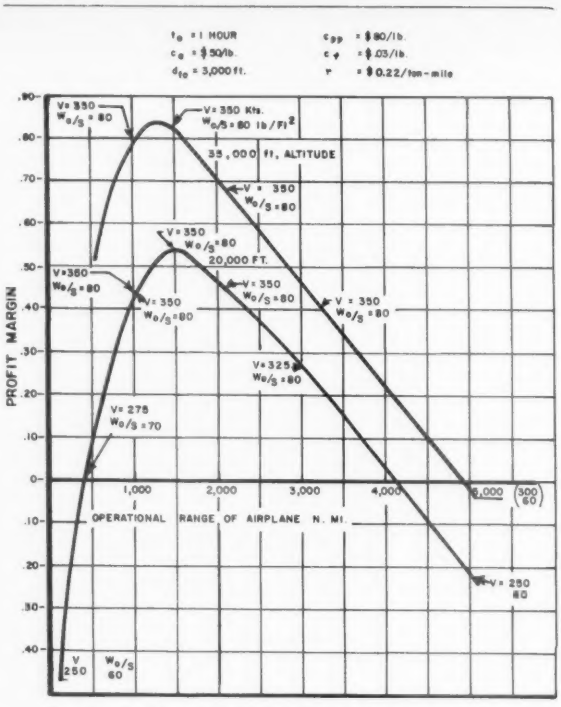

Fig. 1. Maximum profit margin variation with range.

Table 1
Conditions for the Highest Maximum Profit Margin

Altitude, Ft.	Range, Nautical Miles	Velocity, Knots	$\frac{W_{UL}}{W_0}$	Wing Loading, lbs./ft.²	Aspect Ratio* ($\mathcal{R}$)	Profit Margin†
35,000	1,300	350	0.41	80	12	0.83
20,000	1,500	350	0.39	80	12	0.54

* Aspect ratio not parameterized (system relatively insensitive to aspect ratio change).
† Taken from Fig. 1.

essentially a function of the amount of goods carried, number of trips, load factor, and revenue rate. Expressed as a formula in terms of income per pound of gross weight per airplane per year,

$$I_n/W_0N = I_{W_{UL}}(W_{UL}/W_0)(U_0V/R)f$$

The commercial operator is striving to gain a profit by obtaining an excess of income after taxes over costs. The difference between the income and costs is the net gain, expressed by

$$\Delta I_n = I_n(1 - K) - C_S$$

The commercial operator and the investors in the transport system not only are interested in obtaining a profit but are also seeking to gain a net profit over costs, or profit margin. This is expressed as

$$\Delta I_n/C_S = [I_n(1 - K)/C_S] - 1$$

The above equation represents the measure of effectiveness used in this analysis and defined earlier in the paper. The K factor represents the tax rate on income. In this study, $K = 0$.

TABLE 2

	Operational Range (Nautical Miles)							
	500		1,000		2,000		3,000	
Altitude, ft.	20,000	35,000	20,000	35,000	20,000	35,000	20,000	35,000
Profit margin	0.13	0.51	0.44	0.78	0.45	0.70	0.26	0.44
Velocity, knots	275	350	300	350	350	350	325	350
W_0/S lbs./ft.^{2}	70	80	80	80	80	80	80	80
AR	12	12	12	12	12	12	12	12
W_{FL}/W_0	0.445	0.5	0.428	0.47	0.335	0.4	0.26	0.33

SUMMARY OF DATA INPUTS

AR = 12
d_{to} = 3,000 ft.
R = 100–5,000 nautical miles
t_0 = 1 hour, 4 hours
U_0 = 3,000 hours
h = 20,000, 35,000 ft.
V = 200–500 knots
$C_L \leqq 0.8$
K = 0
V_H = 0 and 50 knots
c_0 = 0.545 sea-level static s.f.c., lbs./b.hp./hour
C_{pp} = \$30/lb.
Y = 7 years for air frame, 4 years for engine
c_a = \$50/lb.
c_f = \$0.03/lb.
r = \$0.22/ton-mile
f = 0.75

Personnel, maintenance, and airport facility costs are all lumped into one assumed value of \$10/lb./airplane/year.

RESULTS

The primary results which determine the conditions necessary for the higher maximum profit margin are shown graphically in Fig. 1 and summarized in Table 1. Table 2 contains the summary of the system characteristics for the maximum profit margin cases for various air-line route ranges. The curves of Fig. 1 are composed of the maximum profit margin for the given conditions. In other words, all points on the curves are maximum values; however, one condition yields the greater maximum.

The values given in Table 1, with the exception of altitudes and aspect ratio, are approximate values. The absolute values of the profit should not be taken seriously; however, the relative measures of the values are worthy of note. This is because the costs of maintenance, overhead, and administration are assumed values and do not necessarily represent actual air-line operational cost. The other cost factors, however, appear to be reasonable present-day values. Furthermore, changing equally all costs up or down in value does not change the conditions for a maximum margin of profit. This is also true of revenue variation.

Effect of Wing Loading on the Profit Margin

The wing loading has a powerful influence on all results, as noted in Figs. 1 and 2. It is found that a value of wing loading exists which yields a higher maximum profit margin for a particular velocity and range. The trend toward the higher wing loadings is attributed to the rather high take-off power requirement when compared to the cruise requirement. This affords sufficient power for cruise so that relatively high speeds are the results. The high speeds demand high wing loadings.

The selection of one wing loading value (80 lbs./ft.^{2}) for the 35,000-ft. altitude case at varying ranges is attributed to the C_L limitation. Further discussion on this subject is given in the next section.

Velocity Effect on Profit Margin

The velocity which must be flown to obtain maximum profit margin depends mainly on the range, altitude, design wing loading, and, to a lesser extent, on revenue and cost factors.

All indications show that the maximum profit margin occurs at a velocity of nearly 350 knots for the given system conditions. The rather consistent selection of a velocity of 350 knots at 35,000-ft. altitude for most route range values given in Fig. 1 is attributed to the fact that the lowest q that can be selected and yet remain within the requirement of $C_L \leqq 0.8$ occurs around a q = 129 lbs./ft.^{2}. If the C_L limitation were removed and lower q values were selected, then lower velocities would occur for the maximum profit margins.

Range Effect on Profit Margin

For a given set of cost factors and aerodynamic parameters, a particular range yields a maximum profit margin. In the case given, Fig. 1, the range is about 1,500 nautical miles at 20,000-ft. altitude. A higher profit margin is obtained if the airplane is flown at 35,000-ft. altitude. This is attributed to lower drag and fuel consumption at the higher altitude. The profit

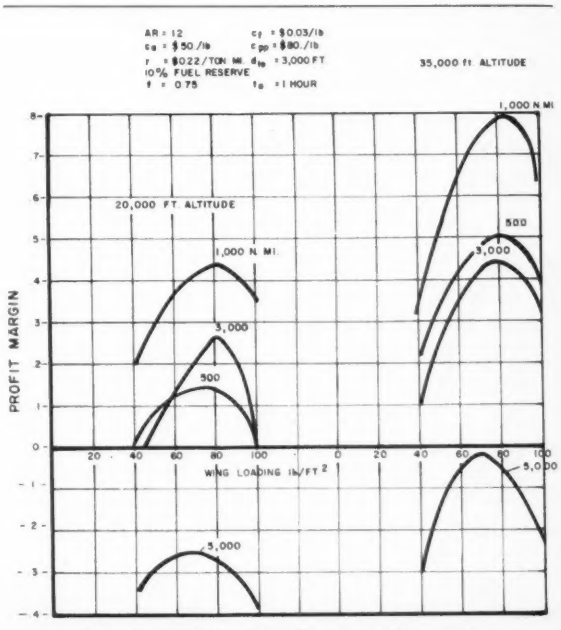

FIG. 2. Wing loading effect on profit margin.

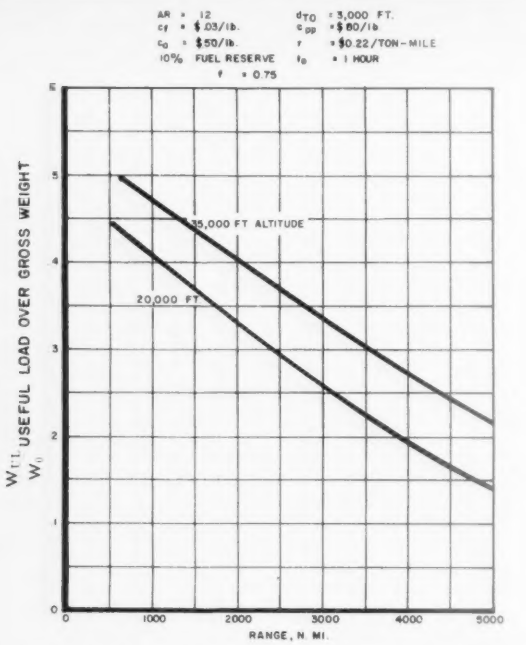

FIG. 3. Useful load ratio for maximum profit over cost.

margin decreases from the maximum value gradually as the range increases and very steeply as the range decreases. This latter effect is caused, to a large extent, by the turn-around or delay time factor. In order for the transport system to maintain a constant maximum profit value throughout the range spectrum without changing the airplane configuration, an increase in the revenue rate proportionate to the profit margin decrease must be made.

Delay Time Factor

The delay time factor has a powerful influence on the profit margin and location of the higher maximum values. Increasing the factor (less delay time) tends to shift the maximum profit value toward a lower range value; decreasing the factor (more delay time) shifts the maximum profit value toward a higher range value. In addition to these effects, the values of profit margin are reduced when the factor is decreased. In fact, the maximum profit margin is reduced about 75 per cent when changing the delay time from 1 hour to 4 hours.

Useful Load Ratio

The useful load ratio (W_{UL}/W_0) varies with the range in nearly a linear fashion. The ratio decreases as the range increases. This is shown in Fig. 3 for the 20,000- and 35,000-ft. altitudes. The curves represent those ratios which produce the maximum profit margin. These curves are useful in determining the gross weight of the airplane. As an example, if a 20,000-lb. useful load is carried for a distance of 3,000 nautical miles at 35,000-ft. altitude, the gross weight of the airplane is 20,000/0.33 = 60,500 lbs. The useful load ratio directly affects the income; thus, greater ratios usually mean greater incomes.

CONCLUSION

The effect of headwinds, cargo load factor, and other parametric effects on the transport system are obtained from this type of system analysis. The analysis, as related here, is by no means complete. What is perhaps more important, the synthesis of economics, employment, and aerodynamic quantities is shown to yield results which differ from those analyses based on separate and perhaps simpler considerations.

This study shows that a turboprop transport system makes the greatest profit margin when it is operated near 35,000-ft. altitude, flies at approximately 350 knots, and is designed with wing loadings in the 80 lb./ft.^{2} region. These data results are subject to some change if certain of the assumptions and design limitations are changed.

A further conclusion follows that the turboprop transport system gains a greater profit margin, assuming a constant revenue rate, if a route range of around 1,300 nautical miles is required, or, in other words, a lower revenue rate can be charged for the 1,300 nautical miles route range and yet maintain the same profit margin as on other route ranges. Also, the use of the minimum cost point as a guide to higher profits is unsatisfactory; nor is it profitable to use the maximum income condition in like manner.

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Rigidity as a Factor in Rate Gyro Mounting (Continued from page 54)

torsion pendulum and a stroboscope or frequency meter. Values for K_{IAg} calculated from measured values of H, J_{OA}, and the natural frequencies ω_{nrg} and ω_{ns} agree quite closely with directly measured values of K_{IAg}.

The air-frame manufacturer should be able to obtain the values used in calculation of R_{gm} from the gyroscope manufacturer, with the exception, of course, of K_{IAm}, the spring rate of the air-frame mounting structure for torques acting around the gyroscope's input axis. Some caution must be observed in measuring this quantity. It should include the whole compliant structure upon which the gyroscope is mounted, the spring rate of the basic air-frame structure as well as that of the collection of brackets which attach the gyroscope to it. For this reason, angular deflection measurements made in determining this quantity should be referred to a reference line on a portion of the basic air-frame structure not deflected by test torques applied to the mounting fixtures.

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Escape From High-Performance Aircraft

The relative trends of airplane performance and escape are compared. Major deficiencies of the escape system, personnel flight equipment combination are summarized.

Introduction

The subject of escape from high-performance aircraft has many aspects. It is not the intention of this paper to discuss any of the moral or psychological aspects of the problem. Rather, it is an investigation of the history of escape in order to establish its trend and possibly determine the controlling parameter for successful escape. I will say briefly that two of the main reasons for an adequate escape system are as follows:

(1) During the development test program of a new airplane, the survival of the pilot may provide the only source of information relative to the sequence of events leading up to the loss of a test airplane. The loss of this information may seriously hamper the expeditious progress of the airplane's development program.

(2) As the airplane becomes operational, a pilot shortage rather than an airplane shortage may be the limiting condition for extensive and prolonged air operations in an "all out" war.

These two reasons, in themselves, are considered adequate to warrant the incorporation of acceptable escape systems in high-performance aircraft.

The Trend in Performance

Before we look into the trend in escape from high-performance aircraft, we will first pause to refresh our memories with the trend in airplane performance. It all started with the Wright brothers. On December 17, 1903, Wilbur Wright attained the speed of 10 knots in level flight. Since that time, progress has been made. According to Fig. 1 there was an average progress in speed of approximately 8 knots per year from 1903 to 1938. With the realization of the potential of the airplane after 1938, the rate of progress increased to approximately 21 knots per year. Prior to the advent of the turbojet and rocket-propelled aircraft, world speed records were attained under approximately sea-level conditions. For the past 6 years, aviation periodicals have reported air speeds attained by aircraft both officially and unofficially which indicate a rate of progress on the order of 100 to 200 knots per year. These air speeds were attained at altitudes well above sea-level conditions.

According to Dr. Fritz Haber, future increases in air speed will necessitate a linear increase in altitude resulting in a Mach Number of 6 at approximately 200,000 ft. altitude. Although the specific trend of maximum air speed in level flight at the present time is not known, it is seen that the advent of the turbojet and rocket-propelled aircraft has resulted in a marked increase in the air speeds attainable in level flight. The next 10 years should be very interesting.

The Trend in Escape

As we look into the trend in escape, let us define what constitutes a successful escape. A successful escape is

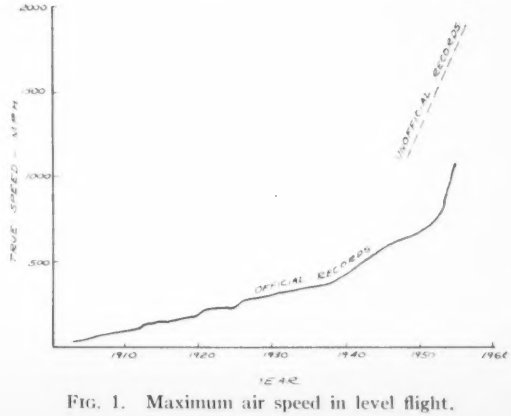

Fig. 1. Maximum air speed in level flight.

* F5D Project Test Pilot.

defined as one wherein the pilot returns to Mother Earth in a physical and mental condition adequate to cope with the environment into which he is forced to descend. He can then optimize conditions in order to facilitate rescue, or, if in enemy territory, he is capable of attempting to prevent being captured. The statistics relative to escape are normally presented on the basis of *fatal, major, minor,* or *no injury.* Within the above definition of a successful escape, fatal and major injuries are considered unsuccessful escapes. On this basis the trend in escape is reviewed.

In the early days of aviation, an emergency condition inflight resulted in the pilot making a "crash landing." Any landing you could walk away from was considered a good landing. For the low stalling speeds and gross weights of these early airplanes, such crash landings were considered a feasible solution to a difficult situation. As the airplane developed over the years and stalling speeds and gross weights increased to meet the demands for more speed and altitude, the feasibility of making crash landings diminished. The high stalling speeds and gross weight of a present-day high-performance airplane—plus its specialized structural design in order to withstand the high aerodynamic loads encountered under normal flight conditions while keeping airplane weight to a minimum—results in the airplane being unable to withstand the abnormal impact loads of a "crash landing." As the airplane comes apart, the airplane systems contribute their fuel and hydraulic oil to an explosion and/or fire that consumes the airplane. The "crash landing" on an unprepared surface of a present-day high-performance airplane is normally fatal to the pilot.

The concept of the parachute was promoted initially to allow the baloonist to escape from his runaway or burning balloon. As the feasibility of making "crash landings" diminished, the parachute was introduced in order to allow the pilot to leave his untenable airplane without accelerating to excessive and normally fatal descent speeds. With the advent of the parachute the concept of escape from high-performance aircraft was born, with the "bail out" as the initial type of escape system. By bail out is meant an emergency escape from an airplane inflight wherein the pilot climbs out of the cockpit or out a convenient door and separates himself from the airplane. After he falls free of the airplane, the parachute is deployed either automatically or manually by the pilot. From 1913 to 1946 the bail out was the only form of emergency escape with relatively little change in technique or equipment during that period.

Looking at Fig. 2 we see that successful bail outs were obtained eleven out of every twelve attempts, approximately 88 per cent successful, during the period from 1913 to 1940. Statistical data during this period are relatively sparse when compared with the quantity of tabulated statistical data available from 1940 to the present day. Since 1940 the percentage of successful bail outs rapidly decreased to less than 40 per cent in 1955. From an analysis of the statistics it was apparent that one of the major factors in the decreasing percentage of successful bail out escapes was caused by the pilot striking parts of the airplane prior to separating clear of the airplane's structure during an escape sequence. It was for this reason that the concept of the ejection seat as utilized by the German Air Force during World War II was brought to this country and tested in 1946. The German Air Force reported that more than 60 combat ejections had been made with this proved device prior to its being utilized in the United States. Initially a successful ejection escape percentage of approximately 70 per cent was realized which decreased to approximately 60 per cent during 1955. The trend in escape versus time indicates an ever-decreasing possibility of attaining a successful escape.

Present Escape Limits

The question now arises as to the limits or practical flight envelope for our present escape system. For the bail-out method of escape, bail outs at equivalent air speeds in excess of 200 knots result in an abnormal decrease in successful escapes. For the ejection method of escape, operational statistical escape data are available for a more analytical determination of the ejection envelope. It is realized that the ejection system has occasionally been referred to as an effective escape system at equivalent air speeds of 600 knots and above. Nevertheless statistical operational experience reveals a decreasing percentage of successful escapes as air speed is increased (Fig. 3). At air speeds in excess of 450 knots there is less than one chance in two that a successful escape may be expected. It is realized that the degree of safety that can be built into a high-performance airplane is a controversial item. Nevertheless I doubt that any serious disagreement will arise if we establish that anything less than a 50 per cent probability of attaining a successful escape is considered unacceptable. It is hoped that future advances in the field of escape will result in a marked increase in the acceptable percentage of successful escapes. In view of this consideration, it is seen that statistical operational experience has revealed the ejection escape system to be unacceptable at equivalent air speeds in excess of 450 knots. The present flight equipment with its limited degree of testing and service experience indicates an altitude limit of approximately 35,000 ft. above which a successful escape becomes more critical.

Ten Steps to Safety

What is causing this limiting condition on our escape system? It may be well at this time to review the ten steps, every one of which must be successfully completed in order that an escape may be considered successful (see Table 1).

Considering the present family of escape systems, it is seen that the successful completion of the first five steps is dependent on the adequacy of the escape sys-

tem design while the last five steps are dependent on the adequacy of the pilot's personnel flight equipment.

An acceptable escape system designed into an airplane allows the pilot to activate the escape system under all flight conditions both normal and abnormal; eliminates the possibility of explosive decompression; applies ejection seat acceleration force within the limits the human can withstand; directs the pilot in a trajectory clear of the airplane structure; and reduces the effects of windblast, tumbling, and deceleration to within the limits of human tolerance. It is after the airplane's escape system has successfully deposited the pilot in the free air stream that the primary purpose for wearing flight equipment is realized. An acceptable flight equipment configuration must first withstand the effect of windblast—i.e., to have an emergency oxygen bail out tear loose because of windblast precludes its expected use as a supplier of oxygen during the descent from high altitude.

After successfully completing this rigid requirement, the flight equipment must include provisions to supply oxygen to the pilot during descents from high altitude; it must insulate the pilot's skin to prevent frostbite; it must reduce the chute-opening shock to within the limits of human tolerance; and it must reduce the rate-of-descent of the pilot to within landing shock tolerances and incorporate provisions to preclude the possibility of being dragged uncontrollably through the water or over rough terrain. Upon successfully returning the pilot to Mother Earth, survival provisions should be available to allow the pilot to sustain life for a period of time commensurate with the environment over which the flight is to be conducted and the availability of air-sea rescue equipment.

TABLE 1
The Successful Escape Sequence

Step No.	Requirement	Critical Conditions
(1)	Activate escape mechanism.	(a) Inability to grasp escape system control handle due to airplane gyrations. (b) Failure of escape system to activate.
(2)	Withstand explosive decompression.	Designed into the airplane as a function of cockpit pressurization ratio, canopy area, cockpit volume and canopy removal geometry.
(3)	Survive ejection acceleration.	Although the ejection seat is designed for a maximum of 20g acceleration, fractures of the spine have occurred at as low as 9g because of alignment and position of the vertebra column.
(4)	Clear the airplane structure.	With a relatively fixed acceleration of the ejection seat and pilot combination, vertical tail clearance decreases with air speed. With the present family of airplanes, air speeds in excess of 450 knots are critical for upward ejection.
(5)	Survive windblast, deceleration, and tumbling.	Escape at air speeds in excess of 450 knots is critical for fatal or major injury because of these phenomena.
(6)	Retain consciousness.	Hypoxia, deceleration, and tumbling may cause unconsciousness.
(7)	Prevent frostbite.	Escape at altitudes above 35,000 ft. is critical particularly for exposed skin.
(8)	Survive chute-opening shock.	The shock of a parachute prematurely opening at high speed or above 25,000 ft. during a free fall can result in fatal or major injury to the pilot.
(9)	Survive landing shock.	Landing in rough terrain or water during conditions of high winds presents a critical condition of survival until the parachute is released.
(10)	Adequate survival provisions on land or sea.	Prolonged delays under adverse environmental conditions.

THE ESCAPE ENVELOPE

With reference to Fig. 4, we can see graphically the escape envelope for present operational airplanes. Outside this envelope critical factors are evident as a function of high speed, high altitude, or a combination of both high speed and high altitude. In the design stage of an airplane that exceeds this escape envelope, additional engineering effort is necessary to increase the present escape envelope. Design consideration with respect to the high-speed critical factors should culminate in an adequate solution to the problems of (1) clearing the airplane structure and (2) reducing the deceleration, tumbling windblast effects, and parachute-opening shock to within the limits of human tolerance.

With regard to the high-altitude critical factors, the designer should provide adequate solutions to the problems of (1) prevention of anoxia, frostbite, and aeroembolism and (2) reducing the parachute-opening shock to within the limits of human tolerance. Flight in the regime of high altitude and high speed results in an additive effect on both high-speed and high-altitude critical factors. The level flight performance envelope of present-day high-performance aircraft greatly exceeds the present escape envelope for both speed and altitude.

THE ESCAPE FACTOR

A graphical comparison of the escape envelope to the level flight envelope of a hypothetical high-performance airplane is shown in Fig. 5. From the presentation we shall define the term Escape Factor as follows:

$$\text{Escape Factor} = \frac{\text{Area of Escape Envelope}}{\text{Area of Level Flight Envelope}}$$

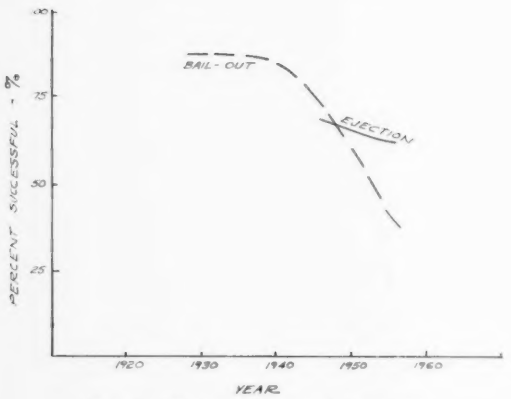

FIG. 2. History of successful escapes.

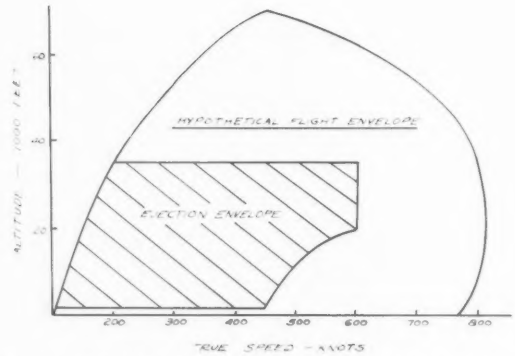

FIG. 5. Comparison of a hypothetical airplane flight envelope to the ejection envelope.

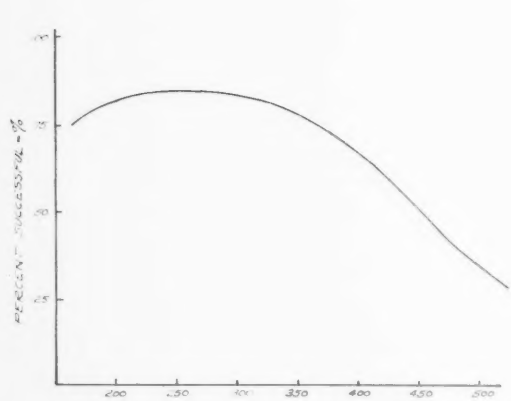

FIG. 3. Effect of indicated air speed on successful escapes.

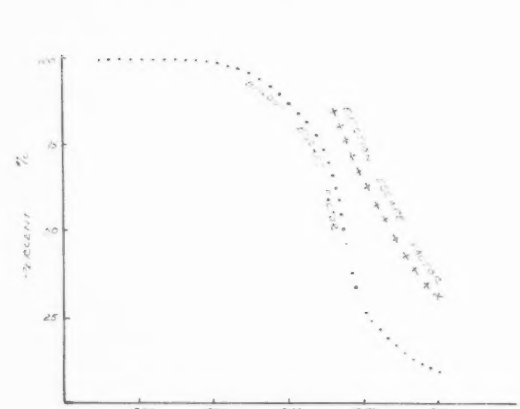

FIG. 6. Escape factor trend.

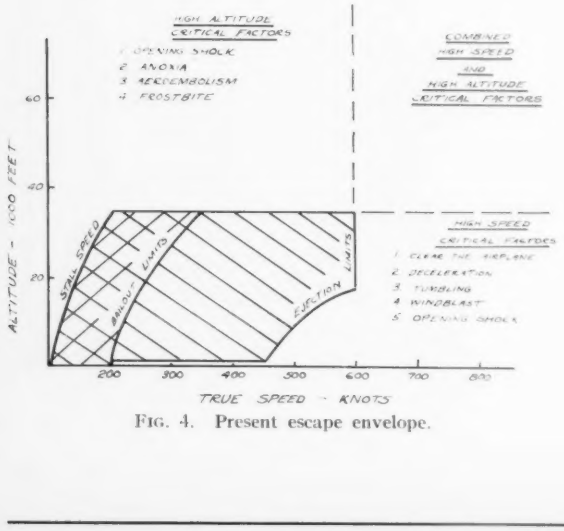

FIG. 4. Present escape envelope.

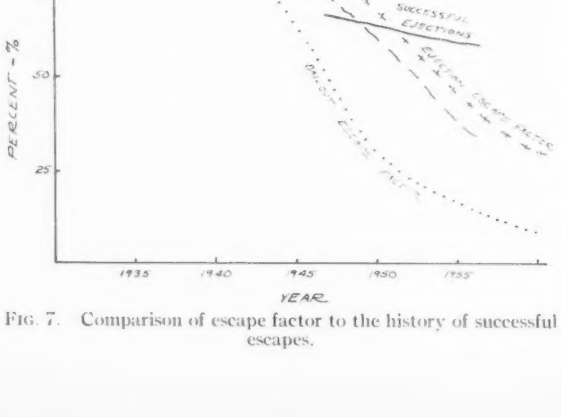

FIG. 7. Comparison of escape factor to the history of successful escapes.

The level flight envelope was selected in lieu of the maximum dive envelope since air speeds in excess of maximum level flight speeds are attained in an extremely small percentage of the airplane's total flight time, whereas for a high-performance airplane, maximum level flight speed conditions are sustained on the majority of operational flight maneuvers.

On the basis of the defined Escape Factor an investigation was made of the bail out and ejection escape envelope relative to the maximum level flight speed envelope for the fastest operational airplanes between the year 1925 and the present day. The resultant trend of Bail Out Escape Factor and Ejection Escape Factor over the last 30 years is shown in Fig. 6. It is seen that the large incremental increases in level flight performance experienced over the past few years while the escape envelope has remained relatively fixed have resulted in a marked decrease in airplane Escape Factor.

Comparison of Escape Ratio to Successful Escape

Upon superimposing the trend in Escape Factor on the trend in successful escapes as shown in Fig. 7, a similarity of trends is apparent between the Escape Factor and per cent of successful escapes. The decrease in Escape Factor is followed by a decrease in per cent of successful escapes. Since the escape data presented are the probabilities of successful escape from the average high-performance airplane, an initial investigation has shown that even closer correlation is obtained by presenting a Mean Escape Factor based on a mean flight envelope derived from a statistical analysis of the total flight hours (total exposure to possible need for escape) for the various high-performance airplane flight envelopes involved in the operational statistics of successful escape. Nevertheless the data as presented indicate a definite trend of decreasing airplane Escape Ratio followed by a trend of decreasing percentage of successful escapes.

Conclusions and Recommendations

From the information obtained in research on the subject of escape, the following conclusions and recommendations are made relative to escape systems and flight equipment.

Basic Research

Much basic research is needed relative to the limits of human tolerance for various possible combinations of human decelerations and gyrations. In addition, the determination of basic aerodynamic coefficients of the human body and human body-escape system combinations similar to the family of coefficients utilized for airplane design is considered necessary in order that the escape system design engineer have the necessary tools with which to design an adequate escape system.

Since there is a common need for this basic information, the National Advisory Committee for Aeronautics is considered the qualified agency to conduct this research.

Escape System Design

While in the drawing-board stage of design, consideration should be given to designing an escape system compatible with the airplane resulting in a *minimum* Escape Factor of 100 per cent. At the present state of the art this requires an adequate solution to the following critical factors of high-speed, high-altitude flight: (1) clearing the airplane structure, (2) deceleration, (3) tumbling, (4) windblast, (5) parachute-opening shock, (6) anoxia, (7) aeroembolism, and (8) frostbite. It is to be borne in mind that, to date, the escape system designer has been unable to attain the predicted 600-knot ejection seat envelope. It is also apparent that all problems capable of solution are solved with the adequate expenditure of engineering man-hours. There appears to be no outstanding characteristic of the problem of escape that indicates a deficiency incapable of solution. It then follows that an increased expenditure of engineering man-hours can provide the necessary solution to the escape problem.

Escape System Testing

Like all other airplane systems, escape systems should be laboratory tested—i.e., they should include rocket sled ejection seat testing for ejection seat escape system, etc.—until 100 per cent successful results are attained. Thereupon, for multiplace airplanes, the escape system should be in-flight tested to the limits of the escape system or to the level flight limits of the airplane, whichever is first encountered. It is expected that the systematic in-flight testing of the multiplace high-performance airplane will obtain a correlation between laboratory testing and in-flight testing to allow the laboratory tests of the single-place airplane escape system to be extrapolated into its in-flight regime.

Such complete test programs are considered relatively inexpensive when compared to the present system of allowing the pilot to test the escape system under actual emergency conditions. Considerable data and time, some pilots, and a certain amount of morale are lost with this type of impromptu determination of escape system deficiencies. Operational statistics reveal that 76 per cent of the actual emergency conditions necessitate an immediate escape rather than a controlled escape from the airplane in the flight regime in which the airplane is flying when the emergency condition arises. These emergency conditions include fire, explosion, loss of control, mid-air collision, and structural failure of the airplane. When the emergency condition arises, a *reliable* escape system must be provided to allow the pilot to make a successful escape. The only way to ensure this reliability is by having a thorough and complete laboratory and in-flight test program.

Flight Equipment Design

Flight equipment design should be considered relative to the combined limiting conditions of the airplane and its escape system. With the present ejection escape system, adequate flight equipment is one half the overall escape problem. The major considerations of flight equipment design are as follows:

(1) No appreciable decrease in pilot efficiency during normal flight operation.

(2) Compatibility with the airplane's escape system.

Flight Equipment Testing

Initial testing of flight equipment should be made under controlled laboratory conditions to determine approximate limitations of the equipment. The second phase should incorporate the flight equipment undergoing test with the laboratory and in-flight tests of its particular escape system. The third and final phase includes in-flight testing under normal operating conditions to determine the degree of decrease in pilot efficiency and if any conflict with pilot control of the airplane exists. Successful completion of these tests is considered necessary prior to releasing the flight equipment for operational usage.

Future Investigations

It is apparent that future investigation work is necessary to amplify the information presented in this paper:

(1) A statistical analysis should be made of airplane flight hours relative to airplane flight envelope in order to devise a Mean Escape Factor for better correlation with operational experience with escape systems.

(2) A study should be made of the expenditure of engineering man-hours on designing and testing escape systems relative to the expenditure of engineering man-hours on the design and testing of the airplane and its remaining systems.

Such a study may reveal the magnitude of engineering man-hours necessary to allow the escape system to "catch up" with the rest of the airplane.

To summarize, we have seen that the high-performance airplane's flight envelope is expanding at a rapid rate, the present escape envelope is relatively fixed, and the percentage of successful escapes is decreasing. Increased expenditure of engineering man-hours is necessary to check this downward trend in successful escape.

In conclusion, it is hoped that the concept of a decreasing Escape Factor predetermining a decreasing percentage of successful escapes is not verified by future operational experience with escape systems.

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The formation of the Joint Committee on Aviation Pathology in November, 1955, and an outline of its objectives as stated by the Department of Defense.

The Role of the Pathologist in Aircraft Accident Investigations†

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Armed Forces Institute of Pathology

THE NECESSITY for a thorough medical investigation of aircraft accidents has long been recognized—in fact a flight surgeon or a medical officer is always a member of the aircraft accident investigation team. In spite of much fine work on the part of engineers, materiel experts, flight surgeons, and others in determining the cause of fatal aircraft accidents, 14 per cent still remain in the "unexplained" category. Further study reveals that this unexplained group accounts for 40 per cent of our fatal accidents. With the advent of high-performance aircraft, it is apparent that our efforts to explain the "unexplained" must be redoubled.

Over the years engineers and materiel specialists have demonstrated the wisdom of a careful examination of every scrap of evidence that can be obtained from the fragments of a wrecked aircraft in order to determine the cause of an accident. Less attention has been given to a careful study of human remains, other than for identification purposes, in order to determine if structural failure of the man may have contributed to the cause of the accident.

In recent years it became apparent that one field of medical science had not been fully utilized as a part of the aircraft accident investigation team. The contribution that the pathologist could make in helping to clarify obscure points relating to the cause of "unexplained" aircraft accidents was made dramatically clear in the investigation of the British Comet disasters in January and April, 1954.[1] From these Comet studies it became apparent that the pathologist could play a vital role in helping to solve some of the problems surrounding a fatal aircraft accident.

The fine study of the British served as a stimulus to an interested few in the United States. Through the efforts of interested flight surgeons and pathologists and under the leadership of Wing Commander Bruce Harvey, the Royal Air Force Medical Liaison Representative with the British Joint Services Mission in Washington, D.C., a group of inquisitive individuals met at the Armed Forces Institute of Pathology in Washington, D.C., in March, 1955, to discuss what could be done in the relatively neglected area which came to be termed "aviation pathology."

At this meeting it became apparent that there was a great deal the pathologist could contribute to the investigation of fatal aircraft accidents that might ultimately be of value in the prevention of future accidents. It was clear that for any real good to accrue from pathological studies of fatal aircraft accidents much painstaking work had to be done. As a matter of historical interest this meeting brought into focus six major problems that must be overcome.

What progress has been made since March, 1955, in overcoming some of these problems?

(1) The need of an administrative mechanism by which the joint efforts of all individuals concerned with aviation pathology could be coordinated was realized by the formation of the Joint Committee on Aviation Pathology established by a Department of Defense Directive in November, 1955.[2] This Committee consists of representatives of the United States Air Force, Navy, and Army; the Royal Air Force; the Royal Navy; the Royal Canadian Air Force; and the Armed Forces Institute of Pathology. Its records are kept at the latter institution.

The objectives of the Committee as set forth in the Department of Defense Directive are to study the available pathology reports of fatal aircraft accidents and initiate detailed pathologic examinations of such

† The REVIEW is indebted to the authors for this abridged version of their original paper, of the same title, presented at the Medical Aspects of Aircraft Accident Investigation Session, 25th Annual Meeting, IAS, N.Y., Jan. 28-31, 1957. The complete work is available from the IAS Preprint Department as Preprint No. 673.

* Deputy Director.

** Section Forensic and Aviation Pathology.

*** Genito-Urinary Section.

accidents in order to evaluate their possible causative role in hitherto unexplained accidents, to observe recurring traumatic lesions which may be preventable, to determine the significance of pre-existing subclinical lesions on air-crew personnel, to investigate possible insidious changes caused by repeated and prolonged exposure to conditions encountered under modern flight conditions, and to establish a long-range program of collecting and rapidly disseminating such information to its member services.

(2) Overcoming the lack of interest in the careful examination and analysis of remains recovered from aircraft accidents is one problem in which progress must of necessity be slow. The education of pathologists—both military and civilian as well as all other personnel, medical as well as nonmedical—is a time-consuming task. Discussions of the subject have been presented before groups of military pathologists and to national civilian pathology societies, as well as the Aero-Medical Association. The scope of the problem has been outlined, and the aid of all concerned has been encouraged. Much more crusading is needed before tangible results can be obtained.

(3) Obviously such education is a fundamental part of the third hurdle—what should a detailed post-mortem examination on an aircraft accident fatality consist of in order to be useful? This was set forth in a memorandum prepared by the Joint Committee on Aviation Pathology and distributed in February, 1956.[3] It emphasized the need for the pathologist to be given detailed information concerning the circumstances surrounding an accident. Only with such information available can he conduct his studies in an intelligent manner. The need of photographs, the necessity of examination of safety equipment, and many other details were emphasized. The usefulness of post-mortem X-rays of fractures when indicated was pointed out. The details of the post-mortem examination even if only a portion of the body was recovered was outlined. The collection of material for chemical analysis of toxic substances was emphasized. This memorandum would serve as a detailed check list for the pathologist in order to eliminate errors of omission. For example, attention was invited to the necessity of pathologic study of the inner ear. Vertigo and spatial disorientation have been described as a cause of some accidents by flight safety experts. Still in no instance has an inner ear ever been removed at post-mortem examination in such an aircraft accident fatality for pathologic study. Such errors of omission will do little to help clarify this perplexing problem.

(4) The lack of service directives has been overcome at least in part by the Air Force through revision of the regulation on post-mortem examination to emphasize the necessity of an autopsy on crew members and others killed in an aircraft accident.[4] An Air Force Regulation has been issued[5] detailing the procedures to be followed in the performance of a post-mortem examination of aircraft accident fatalities. This directive is supplemented by a check list form[6] incorporating all the points set forth in the Joint Committee on Aviation Pathology memorandum referred to above.

(5) The acquisition of trained personnel for these specialized investigations is one problem that requires time to solve. The Armed Forces Institute of Pathology has detailed an Air Force pathologist to devote full time to aviation pathology. In cooperation with other Air Force pathologists an intensive indoctrination program is under way. In order to utilize the resources of the Armed Forces Institute of Pathology to the maximum, the Director of the Armed Forces Institute of Pathology has placed the study of tissues from every aircraft accident post-mortem study in the category of an emergency. The pathologist or other physician who performs the autopsy in such cases may send the tissues for histopathological studies, as well as toxicology examination, direct to the Armed Forces Institute of Pathology without reference to a histopathology center as is routinely the case in all other situations. A toxicology laboratory devoted exclusively to the examination of post-mortem tissues from aircraft accidents has been established at the Armed Forces Institute of Pathology.

(6) Experimental investigation is a sphere in which the chemist and the physiologist have already made considerable contribution, and with the accumulation of good case material and further experimental work the pathologist should be able to contribute more.

The current status of aviation pathology and its related disciplines was brought into focus at a recent 2-day scientific session of the Joint Committee on Aviation Pathology attended by over a hundred military and civilian scientists, engineers, and pathologists from the United States, the United Kingdom, and Canada and held at the Armed Forces Institute of Pathology, November 15, 16, 1956. The discussions and deliberations of this group fell into four general categories:

(1) In the realm of case analyses, a study of 289 gross autopsy reports on file at the Directorate of Flight Safety Research, Office of the Inspector General, United States Air Force, for the 2 years 1953 and 1955, demonstrated that fatal head injuries incurred in accidents occurring during landing and take-off procedures were often the only significant pathologic changes noted. This observation would seem to dictate that further study is in order to evolve better protection for the head at these critical stages of flight. When it is realized that 49 per cent of Air Force fatal accidents occur during landing procedures and 15 per cent during the take-off phase, significance of the correlation of pathological and flight safety data is more apparent.

The need for critical study of bail-out cases was emphasized for in several cases a careful examination by a pathologist for fractures and bruises and a correlation of these observations with material examination have led to a clarification of the sequence of events that occurred in fatal cases of ejection bail-out with consequent light shed on the real cause of the failure. Data of this type can be of great use to our equipment designers for further reference.

A careful evaluation of burns, their extent, degree, and location can be or has been of great value when correlated with the findings of the engineers and materiel experts in arriving at an answer as to where the fire originated, its intensity, and duration.

A study of the pathological findings of 14 cases of death due to in-flight decompression sickness studied by the Royal Air Force Institute of Aviation Medicine and the Armed Forces Institute of Pathology has brought this problem into shaper focus and has dictated the need for further experimental studies of this phenomenon. This work is being actively pursued by the Royal Air Force.

(2) The second category—new techniques—centered around discussions of the use of ultraviolet fluorescence and its possible assistance in the delineation of ante- and post-mortem injuries. Also discussed was the potential role of infrared, the use of the electron microscope in detailed histology studies, and the potential future of enzyme studies on tissues as aids in finding clues as to the cause or sequence of events that may have occurred in an unexplained aircraft accident fatality. The potentialities of these techniques constitute hurdles that are posed for the future.

(3) In the category of the experimental, pilot experiments of the Navy in explosive decompression and autopsy of rats in an altitude chamber at a simulated altitude of 65,000 ft. pose new problems in techniques. The work, though only in its initial phases, has disputed some theoretical hurdles that were forecast. The fixing solution was supposed to boil at that altitude: it did not. The injection of fixing solution and the performance of the autopsy were supposed to be difficult if not impossible at that altitude: they were difficult but not impossible. A much better knowledge of the early pathologic changes that occur in explosive decompression may evolve from this study.

The Royal Canadian Air Force Institute of Aviation Medicine and the School of Aviation Medicine, USAF, have been engaged in a cooperative venture to devise a test on post-mortem tissues that would give some clue as to the existence of ante-mortem hypoxia. The test for lactic acid in brain or spinal cord has shown some promise especially in laboratory animals. It is now in use routinely on all cases in which central nervous system tissue is sent to the Armed Forces Institute of Pathology. The value of this procedure will have to await further study, but here is a definite challenge to our investigators to come up with a test that will give us the answer to those unexplained cases where hypoxia is suspected as the cause of the accidents.

The work at the School of Aviation Medicine, USAF, on the study of tissue electrolytes on animals exposed to low barometric pressures, low oxygen tension, and other conditions simulating the environment of the flyer may give us some leads in solving the problems presented in some of our accidents.

The toxicologist is presented with the challenge of determining whether carbon monoxide really plays a role in jet aircraft accidents. The finding of high tissue carbon monoxide levels in several unexplained accidents presents a problem of determining its source. Much study has been accomplished on the subject of carbon monoxide in jet aircraft; more is needed before the question can be answered.

(4) The clinical observations of Col. William H. Lawton, USAF (MC), on the role of hyperventilation and hypoglycemia as causative factors in fatal aircraft accidents have reflected themselves in a reduced accident rate where educational and corrective measures have been introduced.

With the foregoing as the general background on the role of the pathologist in aircraft accident investigation, the question may be posed as to what approach must be taken in the consideration of data. For the purposes of simplification it is felt that three main factors must be kept in mind by the pathologist in the investigation of any aircraft fatality—environmental factors, traumatic factors, and pre-existing disease.

Environmental factors relate to such items as the altitude and speed of the aircraft, the possible effect of *g* forces, the presence of toxic materials, extremes of temperature, noise, and stress.

A consideration of traumatic lesions can be significant when the data from a large group of cases are analyzed. A careful appraisal of traumatic lesions is of extreme importance in cases of fatal bail-out. In this general area of endeavor the observations of a skilled pathologist can be of inestimable value when correlated with the observations of the engineers, the materiel specialists, and others of the investigating team.

Pre-existing disease obviously can play an important role in its influence on the flyer. There are several cases of otherwise unexplained accidents in the files of the Armed Forces Institute of Pathology in which there is definite evidence of coronary artery disease. In a recent case, an acute coronary thrombosis occurring in the pilot and discovered at autopsy cleared up what was otherwise a mystifying accident.

In summary, it may be concluded that the pathologist will be a valuable addition to the aircraft accident investigating team. It would be absurd to expect that the pathologist offers a solution to all of the problems confronting the aircraft accident investigator, but it is anticipated that, properly utilized, he will be a most useful, if not indispensable, adjunct.

References

[1] Armstrong, J. A., Fryer, D. I., Stewert, W. K., and Whittingham, H. E., *Interpretation of Injuries in the Comet Aircraft Disasters, An Experimental Approach*, Lancet, Vol. 268, pp. 1,135–1,144, June, 1955.

[2] U.S. Department of Defense Directive, No. 5154.11, November 14, 1955.

[3] Memorandum No. 1, Joint Committee on Aviation Pathology, Armed Forces Institute of Pathology, February, 1956.

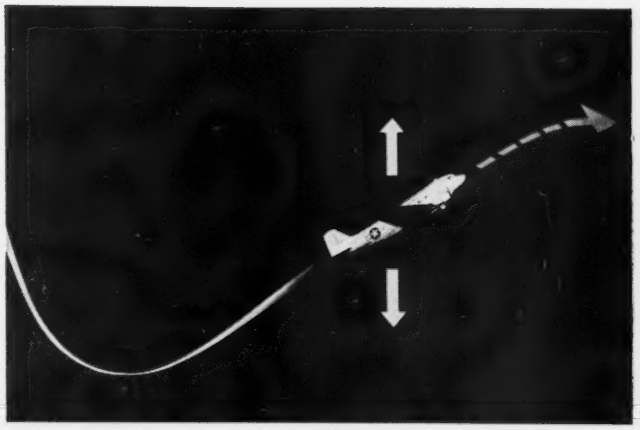
[4] Air Force Regulation No. 160-35, Department of the Air Force, Washington, D.C., June 22, 1956.

[5] Air Force Regulation No. 160-109, Department of the Air Force, Washington, D.C., October 12, 1956.

[6] Air Force Form No. 500, Department of the Air Force, Washington, D.C., October 15, 1956.

Weightlessness — *What it is and what Douglas is doing about i*

When man invades outer space where neither normal gravity nor atmosphere exist, strange things will occur. Automatic functions—swallowing or even breathing—will demand the space traveller's deliberate thought. Exhaled carbon dioxide may smother him. Liquids won't flow, and undiffused sunlight will bathe him in a searchlight glare as micro-meteorites streak past at 50 miles per second. Such problems in the physiology and psychology of space travel have been an active concern at Douglas, ever since this Company's engineers—in 1946—first designed an earth satellite for the military.



To study the problem of life without weight, Douglas engineers early proposed flying a curve in which the pilot was so balanced between gravity, centrifugal force, and drag that he could experience a *weightless* state. The USAF has conducted such experiments in a Douglas C-47. The record for a pilot is now 47 seconds, although weightlessness has been survived by animals for many minutes.

Forerunner of a practical space suit is the Navy's T-1 high altitude suit, designed by Douglas engineers for test pilots who undergo forces where a 200-pound man weighs more than half a ton and at altitudes where his blood would boil. The T-1 which has undergone pressure chamber tests equal to an altitude of 20 miles up, is only one of the projects completed at Douglas to speed the day when man will travel through space.

Depend on

DOUGLAS

first in Aviation

Frank Mansur (M), former Director of Marketing, Eitel-McCullough, Inc., has joined Lewis and Kaufman Ltd., Division of International Glass Corp., as division General Manager. Mr. Mansur also is a member of the *Aeronautical Engineering Review* Editorial Advisory Committee.

News of Members

(Continued from page 23)

appointed a member of the U.S. Army Scientific Advisory Panel.

Y. C. Lee (M) has been appointed Director of Research and Planning, Liquid Engine Division, Aerojet-General Corporation. He also was named to the NACA subcommittee on combustion.

Donald W. Male (M), Chief, ARDC Arnold Engineering Development Center, Plans Division, has been awarded a Sloan Fellowship to attend Massachusetts Institute of Technology School of Industrial Management.

Thomas R. Marks (M) has been appointed executive Assistant to W. Waits Smith, Vice-President in charge of Westinghouse Electric Corporation's Aviation Gas Turbine Division. He formerly held a supervisory position in the Preliminary Design Division of the Engineering Department.

Arthur E. Miller (M) has been promoted from Chief Engineer to Director of Research at Scott Aviation Corporation.

Robert B. Phillips (A), formerly Director of Training and Technical Manuals, National Airlines, Inc., has been promoted to Director of all Training and Technical Publications for National.

George F. Rugge, Jr. (A), Missile Test Engineer, Flight Test Group, Convair, A Division of General Dynamics Corporation, has transferred to the Astronautics Division where he will be Senior Service Engineer at Patrick Air Force Base, Fla.

Vernon I. Weihe (M), former Technical Assistant to the Vice-President in charge of Engineering, Melpar, Inc., has joined the Avionic Division of General Precision Laboratory Incorporated. He will direct GPL's Avionic Systems Planning activities from Washington, D.C.

Robert L. Wells (AF), formerly Executive Assistant to the Vice-President in charge of Westinghouse Electric Corporation's Aviation Gas Turbine Division, has been named Manager of the firm's Atomic Power Department, Pittsburgh.

H. Charles Yaeger (M), formerly Works Manager, Pesco Products Division, Borg-Warner Corporation, has joined Vickers Incorporated as Plant Manager of the firm's new Jackson, Miss., plant.

Leslie E. Neville (M) has been appointed Corporate Director of Advertising, Customer and Public Relations, American Bosch Arma Corp. He had been Arma Division Director of Public Relations and Advertising.

Necrology

Chester W. Gates, Jr.

Word has been received of the death of Commander Chester W. Gates, Jr. (A), killed in a Navy jet crash July 10, 1956, He was 35.

A native of Florida, Commander Gates was graduated from the U.S. Naval Academy in 1942, and from California Institute of Technology, where he studied aeronautical engineering, in 1954. His hometown was Baldwin City, Kan.

Modesto Panetti

News has been received of the death on March 26 of Modesto Panetti, a past Fellow of the Institute and a pioneer in Italian aeronautical studies. He was 82.

A few years after the Wright brothers' first flight, Dr. Panetti founded the School of Aeronautical Engineering (1912) at the University of Turin. He also set up the school's Aeronautical Laboratory.

Born in 1875 at Acquaviva delle Fonti, Bari, he graduated as a civil engineer at Turin in 1896. The university conferred upon him a Doctorate in Mathematics in 1899.

He was named Professor of Theoretical and Applied Mechanics at Genoa Naval School in 1909, but in 1910 he returned to Turin as Professor of Applied Mechanics of Machinery. He was Faculty Chairman and Professor Emeritus at Turin Polytechnical School, the former from 1935 to 1945, and Director of the Center for the Study of Fluid Mechanics there.

He founded the National Research Council at Turin and was President of the Italian Thermotechnic Association, Vice-President and Honorary Associate of the Italian Aerotechnic Association, an Associate of the Air Transport Association, and a Senator of the Republic.

Dr. Panetti was affiliated with several other scientific organizations in Europe and received many honors for his scientific contributions.

CORPORATE MEMBER NEWS

•**Aerojet-General Corporation** has announced the appointment of James C. Sampson as Head of the new Infrared Projects Department of the Avionics Division.

•**Aircraft Radio Corporation** has announced a completely transistorized unit with no moving parts, the DVIOA Dynaverter, that weighs only 1.6 lbs. The firm says it will replace dynamotors in nearly all ARC aircraft radio and navigation receivers. Brochure ARCBR-T20-1, just out, describes the firm's new "building block" 20-channel VHF transmitter.

•**Allis-Chalmers Manufacturing Company** has published a new bulletin describing its Ultra-Speed package drive unit. Copies are available by writing for Bulletin 51B8166A, Allis-Chalmers, Milwaukee 1, Wis.

• **Allison Division, General Motors Corporation,** has named Robert L. Hahnke Manager of Commercial Sales for the European area.

• **American Airlines, Inc.,** has announced new one-stop DC-7 flights from Boston to San Francisco, and two nonstop flights between New York and St. Louis. The firm also says that it will expand facilities at its Tulsa overhaul base to accommodate prop-jet and turbojet aircraft.

• **Arma, a division of American Bosch Arma Corporation,** has announced that Clifton T. Foss, formerly Vice-President and Division Manager, has been elected

THE FLIGHT HEARD 'ROUND THE WORLD

Recently three B-52 bombers flew around the world in 45 hours and 19 minutes. They were only specks in the vastness of the sky, yet they were in voice-contact every mile of the way—with SAC headquarters in Omaha, with each other, with bases along the route and with the KC-97 tankers that refueled them in the air.

Their speed-of-light contact was the AN/ARC-21 liaison communications set in each of the ships. This is a long-range, pressurized, high-altitude airborne system, capable of world-wide communications. It may be operated by the pilot, so no radio operator is needed. It is characterized by minimum training requirements, simplified maintenance, high reliability, positive channel selection —with a choice of any 20 of 44,000 frequencies.

In this as in other ways, RCA serves our Nation's armed forces. RCA scientists and engineers are constantly creating, designing and producing new and better electronic systems and equipment.

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DEFENSE ELECTRONIC PRODUCTS *CAMDEN, N. J.*

Aircraft mechanics at Convair, A Division of General Dynamics Corp., San Diego, are assembling a 20-ft. long full-size metal section of the fuselage for the Convair 880 jet transport. It will be used to test the cabin air conditioning system and soundproofing.

a Corporate Vice-President in charge of defense product planning. Ernest A. Goetz has been promoted from Assistant Chief Engineer to Chief Engineer. E. D. Gittens former Vice-President—Engineering will replace Mr. Foss.

• **Avien, Inc.,** has announced an over-temperature recorder for jet engines designed to aid in resolving the conflicting requirements of maximum engine efficiency and flight safety. Designated TTR System, the firm says it monitors any single, group, or range of engine temperatures against permissible duration time specified by the engine manufacturer.

• **Bell Aircraft Corporation** reports that it has made a breakthrough in modular packaging techniques with the development of a rugged 400-mc. receiver. This may be used where it is necessary to have demodulated control signals for activation of any communications system requiring a high signal-to-noise ratio, high sensitivity, high stability, and a wide bandwidth with low harmonic and phase distortion. Application is in missile and guidance systems where vibration has presented serious problems.

• **Bendix Aviation Corporation,** Eclipse-Pioneer Division, has formed a new B-58 systems department with James B. Treacy as Manager. . . .Theodore Voorhees has been appointed General Manager, International Division. . . .Radio Division has announced completion of a direct sales and licenses agreement with Computing Devices of Canada Limited. Under the agreement CDC will handle Canadian sales of the division's aviation electronic products. A. E. Abel has been appointed General Manager of the division. . . .Scintilla Division has announced plans for a $5 million expansion of its Sidney, N.Y., plant. . . .Products Division research laboratories are using a massive combination drop test and brake dynamometer capable of simulating speeds, shock loads, and kinetic energy of a complete aircraft landing gear, strut, wheel, and brake.

• **Boeing Airplane Company** reports that it has solved the problem of locating "blind" holes in nonferrous structural parts by the development of a tool named Blindriller. William L. Morse, a Boeing Manufacturing Research Engineer, designed the tool to operate on a magnetic detection principle. A small magnet inserted in the hidden hole in the structural member is found by the new device which contains another magnet of opposite polarity. . . .Training classes to acquaint operating personnel with eight modern spar mills have begun at Seattle Division. The firm also reports delivery of two KC-135 jet tankers to the Air Force, the first to be turned over to an outside using agency.

• **Chance Vought Aircraft, Incorporated,** has announced creation of two chief engineering posts for aircraft and guided missiles. J. Russell Clark is Chief Engineer—Aircraft and Samuel O. Perry, Chief Engineer—Missiles. J. R. Silverman has been named Executive Assistant to the Vice-President—Production. The firm also has announced an "aid to education" program for high school graduates entering engineering fields. It establishes ten $1,000 and scholarships a year for 30 high schools in the Dallas-Fort Worth area and 50 working scholarships (a technical cooperative program) with Arlington State College to cover a span of 5 years.

• **Curtiss-Wright Corporation** has announced the appointment of Ringer-Mezger Co., Inc., as sales representative for northern New Jersey, metropolitan New York, and Long Island for its line of electronic instruments.

• **Douglas Aircraft Company, Inc.,** is providing liquid oxygen instead of tanks of gaseous oxygen for crews of three high-altitude carrier-based aircraft. The new system requires less than half the space of heavy steel tanks and operates at very low pressures. It converts the liquid to usable gas for crew requirements and weighs three fourths less than tanked variety. . . .A lightweight tail-cap antenna used in military aircraft will be adapted for use in the DC-8, the firm reports. . . . Royal Dutch Airlines and Panair do Brasil took first deliveries of two DC-7C's. . . . .Charles R. Strange has been appointed Chief Engineer and Anthony G. Puglisi, Assistant Chief Engineer at the Tulsa Division. . . .Two new Vice-Presidents elected by directors of the firm are John A. Dundas, General Counsel, and M. E. Oliveau, Director of the firm's European Division.

• **The Dow Chemical Company** reports that its 13,200-ton magnesium extrusion press, claimed by the firm to be the largest in the world, filled its first production order—18-in. structural sections for experimental landing mats. The big press was one of several under construction at Duisberg, Germany, at the close of World War II. Parts scattered over most of Germany were regathered. Karl T. Braueninger, one of a group of German light-metals engineers who worked on it since its inception in 1942, is Manager of Dow's extrusion operations.

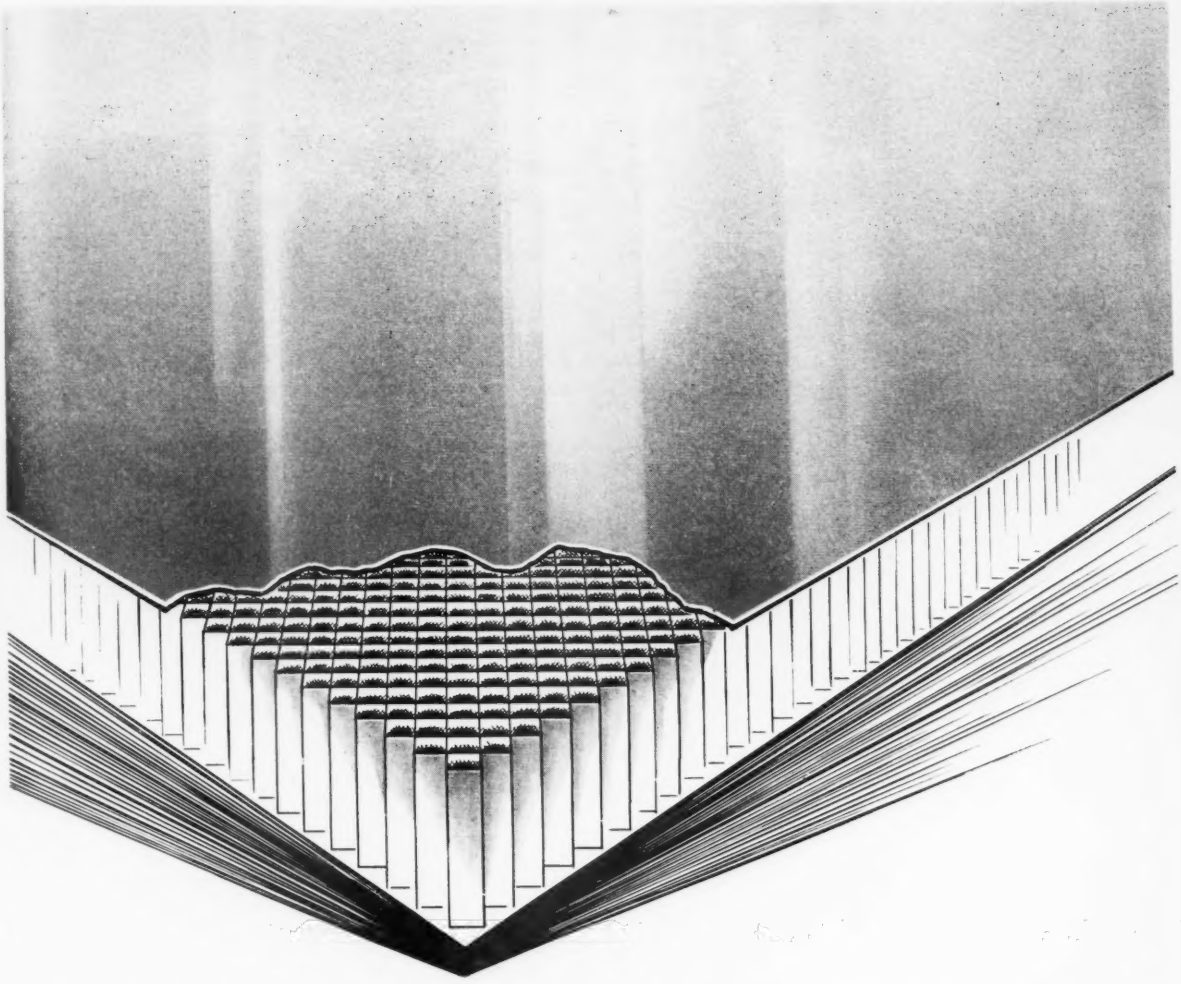
• **Eaton Manufacturing Company** has announced plans to build a new test laboratory for research and development of components for aircraft turbojet and industrial gas-turbine engines at the Fredric Flader, Inc., Division, North Tonawanda, N.Y.

• **Fairchild Camera and Instrument Corporation. .** John Carter, 37-year-old Vice-President of Corning Glass Works, has been elected President of the firm. He succeeds Sherman M. Fairchild (F) who had been serving as President for 5 weeks after the resignation of John H. Clough.

• **Fairchild Engine and Airplane Corporation** has announced plans for prototype production of a four-engined turboprop transport to be known as the Turboboxcar. Lycoming T-55 engines will be used. Take-off gross weight will be 75,000 lbs., and it will carry 32,181 lbs. of cargo over short ranges and 21,439 lbs. at maximum range of 1,500 miles. Cruising speed will be 216 knots, operational altitude 25,000 ft., normal take-off distance 2,240 ft., landing 2,050 ft., over a 50-ft. obstacle. With boundary-layer control these latter distances will be 1,750 ft. at take-off and 1,610 ft. at landing.

• **The Garrett Corporation,** AiResearch Manufacturing Division, has designed a new lightweight type of turbine-driven fan to provide comfortable cabin temperature in Boeing's 707 jet air liner. The division also has announced development of a tiny $1^1/_4$-lb. unit, designed to convert electronic signals into control forces for guided missiles, drones, or aircraft. Called a time dwell servovalve, the unit will serve as a link between a missile's electronic computer and control surface actuators regulating flight path. . . .AiResearch Aviation Service Division will convert five Mohawk Airlines Convair 240's to accommodate more passengers and improve passenger convenience.

• **General Dynamics Corporation** has announced the death on May 3 of John Jay Hopkins, 63, Chairman of the Board. . . .Canadair Limited (Subsidiary)



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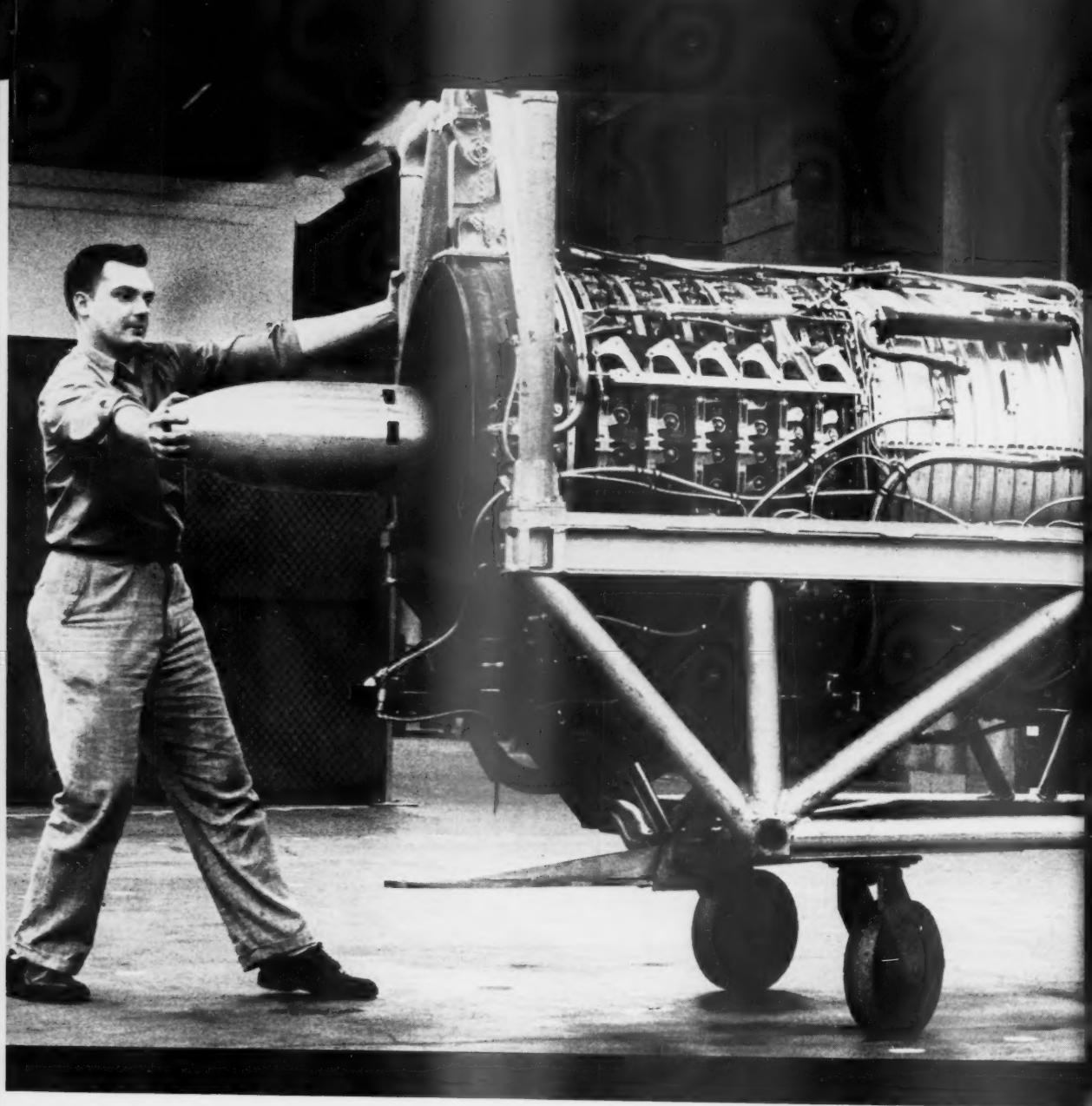

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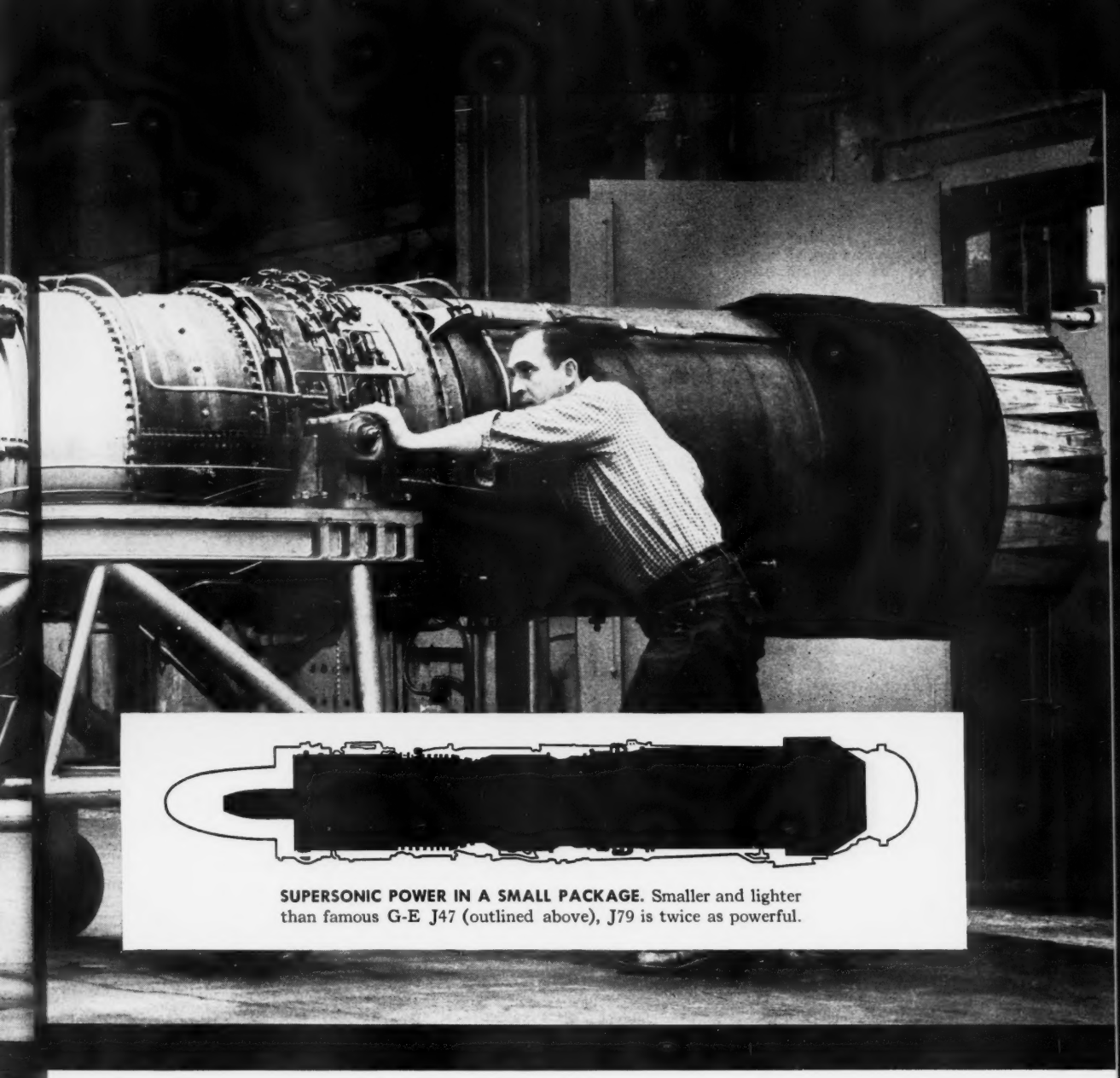

SUPERSONIC POWER IN A SMALL PACKAGE. Smaller and lighter than famous G-E J47 (outlined above), J79 is twice as powerful.

Washington, D.C., May 21—The General Electric J79—first U.S. jet engine capable of powering aircraft twice the speed of sound—was displayed publicly for the first time today. Rated in the 10,000 lb-thrust-class, the lightweight J79 has the lowest specific weight of any U.S. production turbojet.

Answering military demands for a mechanically-simple, high thrust-to-weight jet engine, J79 features include:

• **Variable stator**—To eliminate stall problems at "off-design" speeds and permit maximum compressor efficiency under all flight conditions, the first six stages of the 17-stage J79 compressor are variable.

• **Small frame size**—J79's diameter is less than three feet, its length about 17 feet.

• **Small hub diameter**—enables J79 to combine reduced-drag advantages of narrow frontal area with high airflow capacity.

Today powering USAF's Lockheed F-104A, Convair B-58, and the Grumman F11F-1F, the J79 continues to set the pace for America's jet powerplants.

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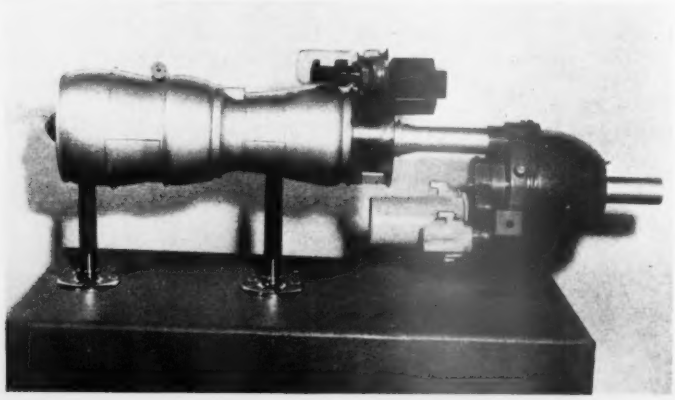
GENERAL ELECTRIC

will re-enter the commercial aviation field with production of a new version of the Bristol Britannia, the CL-44, powered by four Bristol Orion turboprop engines. Air liner, freighter, and military transport configurations will be produced. . . . Stromberg-Carlson Division has developed a new system for automatic transmission of flight information from aircraft to ground control centers. Called LABIL (Light Aircraft Binary Information Link), the division reports it enables a pilot to transmit automatically 13 separate categories of flight information to a control tower with the flip of a switch. . . .Convair Division announced that a new "aerial bobsled" ejection seat for century-series jet fighters is being developed by the Industry Crew Escape Systems Committee. The new seat which projects the pilot feet-first, on his back into the supersonic air stream, is aerodynamically shaped and equipped with stabilizing fins. Thirteen major aircraft firms and subcontractors are participating in the development program. . . .John W. Bond, Jr., has been appointed Chief of the Physics Group at Convair San Diego. . . .Convair Fort Worth has delivered the last B-36 in the SAM-SAC maintenance and modernization program.

• **General Electric Company** Research Laboratory has announced that a silicon carbide rectifier has been operated at temperatures up to 1,200°F. The Specialty Control Department is producing a new line of high-horsepower Thymotrol adjustable speed drives for use on aircraft test stands. . . .Defense Electronic Division announces a new type of airborne armament comprised of two kits containing .308-caliber machine guns and small rockets and designed to give helicopters defensive protection. Developed by engineers in the Missile and Ordnance Systems Department, each kit is said to be portable and light for use as a regular field weapon when detached. The department also announced completion of a new $1.5 million facility for assembly and testing of high-precision radar antennas. The division's Aircraft Products Department has been integrated into the Light Military Electronic Equipment Department. This department's newly established Armament & Control Section is headed by M. R. Johnson, appointed Manager. . . .Apparatus Sales Division has a new development laboratory for testing aircraft electrical systems. Its Gear Motor and Transmission Components Department has announced a new shaft-mounted speed reducer for applications where complex multiple reduction belt or chain drives are needed. Instrument Department engineers have developed a new method to measure generator field temperature by combining a known electrical principle with standard recording instruments. The Distribution Assemblies Department has published a revised 24-page bulletin (GEA-6367A) describing in detail a compactly designed general-purpose motor control center said to permit savings up to 50 per cent in floor area. . . .Electronic Components Division, Semiconductor Products Department, has developed a line of 170°C. stud-mount silicon rectifiers for use in military and commercial equipment power supplies. Hugh R. Lowry has been appointed Manager of Application Engineering for the department.

Lear, Inc., LearCal Division, reports its new permanent magnet alternator for aircraft and guided missiles has extreme durability and reliability, excellent wave form, and ability to recover from dead shorts without effect on voltage or performance.

General Electric Company's Small Aircraft Engine Department is developing a two-in-one aircraft gas turbine, a scale model of which is shown, for the Navy. The engine is designated the T64 and will be both a turboshaft and turboprop power plant for helicopters, transports, and other support aircraft.



• **General Precision Equipment Corporation,** General Precision Laboratory Incorporated (division), has developed an automatic iris and target control unit for its industrial and institutional television system. The unit is said to weigh 13 lbs., automatically compensate for wide variations in light up to 16,000 to 1, and assure lowest possible aperture to provide maximum resolution, depth of field, and contrast.

• **The B. F. Goodrich Company** Board Chairman John L. Collyer has announced that estimated capital and investment expenditures of $41 million is planned this year.

• **The Goodyear Tire & Rubber Company, Inc.** . . .Harold L. Flowers has been named manager of the newly created Weapons Systems and Forward Project Planning Department.

• **Grumman Aircraft Engineering Corporation** has announced a permanent subcontracting program with work complete and under way totaling more than $7 million. The firm's F11F-1 Tigers have replaced Cougars in the Navy's precision flying team, the Blue Angels.

• **Jack & Heintz, Inc.,** has issued a new Aircraft Equipment catalog containing pertinent design and performance data on some 100 in-service models of several equipment lines. Copies are available by writing the firm at 17600 Broadway, Cleveland 1, Ohio.

• **Walter Kidde & Company, Inc.,** has moved operations of the Thermalectric Engineering Division from Van Nuys, Calif., to the Aviation Division at Belleville, N.J. The Thermalectric name is being dropped, and the thermal switches, heat detectors, and other products will be made in Belleville and marketed under the trade name Kidde. The firm also has published a new booklet describing lightweight aircraft compressors; it is available by writing to the Aviation Division, Belleville, N.J.

• **Lear, Incorporated,** Lear-Romec Division, is manufacturing a pump for scavenging and lubricating components of aircraft engines, Model RR16240, six-element power-driven rotary vane pump. . . .Grand Rapids Division has announced development of control force sensors said to augment the naturalness of control from the stick with the smoothness and precision of automatic flight controls.

• **Lockheed Aircraft Corporation's** Starliner has been CAA qualified. The Model 1649A was certificated in 51 days involving about 165 hours in the air. Vernon A. Johnson has been appointed Director of Corporate Outside Offices. He also is Assistant to the President and Manager of the firm's Washington office. Lockheed scientists are conducting experiments with gunpowder (explosive-forming tests) to provide answers to manufacturing problems. . . .Roy Mackenzie is the new Manufacturing Manager of the Georgia Division. . . .Missile Systems Division appointments include Ronald Smelt, Director, New Design Office, Research and Development Branch; John P. Nash, Manager, Information Process-

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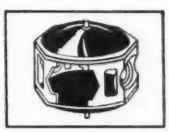
Outstanding in reliability and accuracy, the Giannini Model 3416 Free Gyro has been designed for today's most advanced airborne control and telemetering systems. Now in quantity manufacture, it has been chosen as standard equipment on production missiles and is used for flight test instrumentation on a number of aircraft. From its precisely balanced rotor-gimbal system to its rugged structural outer shell, this instrument offers more significant features than any other free gyro available.



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having compatible temperature coefficients and providing structural rigidity.

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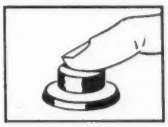
for simultaneous measurement of angular displacement in two mutually perpendicular axes.



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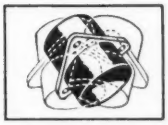
with indicator circuit for each.



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due to precise dynamic balance, structural strength and CG mounting.

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Giannini GYRO DIVISION

G. M. GIANNINI & CO., INC. 918 EAST GREEN STREET • PASADENA, CALIFORNIA

ing Division, R&D; and Joachim W. Muehlner, Consulting Scientist, R&D.

• **Manning, Maxwell & Moore, Inc.,** Aircraft Products Division has developed Type 141F12 Rotary Torque Booster, said to provide failure-proof hydraulic amplification for control system designers. Normal operation includes pressures from 150 to 500 psig, but it is applicable to greater torque requirements upon request.

• **Marquardt Aircraft Company** reports that four members of its engineering staff have been named to NACA technical subcommittees during 1957. They are Don L. Walter, Vice-President—Engineering; John A. Drake, Director of Research; R. T. Dungan, Research Engineer; and William J. Bennet, Thermodynamics Engineer.

• **The Martin Company. . .**Howard W. Merrill, Director of Operations, Baltimore Division, has been named a Vice-President of the firm and General Manager at Baltimore. He succeeds William B. Bergen, who remains Executive Vice-President. . . .Matadors now in service are being replaced by an improved version, the TM-61C, with a better guidance system. Cost is about $60,000 per missile. . . .Martin and Bendix Aviation Corporation have built a new milling unit air-frame production automation system, said to be the first in the country. It is called the first practical application of a punched-tape control system to a three-dimension milling machine or any other large-scale machine tool. Baltimore Division will use the system on production of Matador missiles and the P6M SeaMaster. It is expected to eliminate many weeks of tool-setup and tool-change time. The system is electronically controlled.

• **Minneapolis-Honeywell Regulator Company** has flight tested what it calls a new "pure" inertial navigating system for automatic guidance of manned or unmanned aircraft. An Aeronautical Division project, the system is designated ISIP, is self-contained, and is not dependent on outside sources, radar, star-tracking, or radio commands. . . .John W. Anderson has been named Director of Engineering for the firm's inertial guidance facility near St. Petersburg, Fla.

• **Norden-Ketay Corporation** has announced a new jet fuel flow measurement system, IF-1 indicator, which—when matched with eight Norden-Ketay TF-2 transmitters—is said to register up to 100,000-lbs./hour with extreme accuracy over the entire range. The firm has published bulletin 424 which gives specification and installation drawings of ten jet aircraft instruments meeting military specification. Rate of fuel flow transducers for single-engined aircraft also are available.

Latest of Lockheed Aircraft Corporation's transports is the Model 1649, with a 150-ft. wing, scheduled to enter Trans World Airlines service July 1 as the "Jetstream." Twenty-four more will be delivered to TWA in October.

• **North American Aviation, Inc. . . .**Atomics International Division has announced that self-sustaining nuclear fission was achieved in the Sodium Reactor Experiment project. . . .Autonetics Division has announced the appointment of Charles L. Backus, Jr., to manage its Dayton branch office. . . .Rocketdyne Division is developing high thrust rocket engines for the Army's Jupiter missile.

• **Northrop Aircraft, Inc.,** has established a new division, Northrop International, with J. Gilbert Nettleton, Jr., elected corporate Vice-President and assigned responsibility for the management of the division. . . .The firm's Utah office has been moved to the First Security Building, 2406 Washington Boulevard, Ogden. . . . The firm reports that an Air Force Northrop F-89D has become the first-known jet to land on a frozen sea. The landing was made without incident during a test on 48-in. thick ice on North Star Bay, a few miles from Thule, Greenland.

• **Pan American World Airways, Inc.,** Atlantic Division has announced plans for an $8 million air terminal at New York International Airport, to be completed in 1958. For Pan American flights only, the terminal is said to be revolutionary in design, incorporating an oval-shaped 4-acre cantilever roof supported by 32 piers and able to handle a 160-passenger air liner every 15 min.—all under the one roof.

• **Pesco Products Division, Borg-Warner Corporation,** has announced that it will be exclusively devoted to engineering and production of hydraulic, electric, air, and fuel accessories for military aircraft, commercial air liners, rockets, and guided missiles.

• **Reaction Motors, Inc.,** is developing an advanced-design liquid propellant rocket engine for the North American Aviation, Inc., X-15 research airplane. . . .Edmund B. Parke has been appointed Director of Production Division.

• **Republic Aviation Corporation** has formed a specialized staff of "tomorrow thinkers" for research on problems of flight at thousands of miles per hour and at altitudes 50 miles above the earth. The group, called the Scientific Research Staff, is organized into four main sections: nuclear physics, applied mechanics, electronics, and aerophysics.

• **Ryan Aeronautical Company** has announced its X-13 Vertijet has accomplished in complete operational sequence all aspects of jet VTOL flight.

• **Servomechanisms, Inc. . . .**The Cornerstone for a new Eastern Subsystems plant has been placed. The plant will house engineering, manufacturing, and administrative departments, laboratory facilities, prototype and model shops, and a precision production machine shop. A single-story garden-type building, it is scheduled for occupancy this fall.

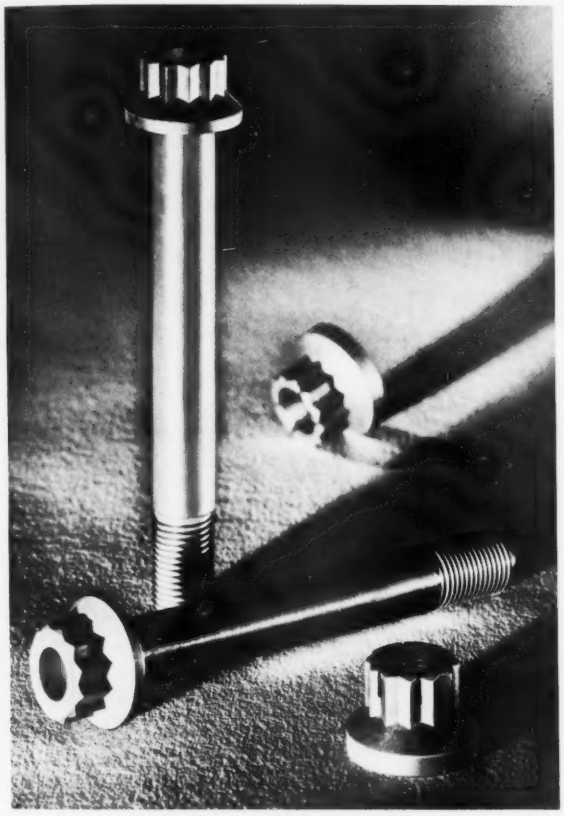
• **Shell Oil Company** has sent eleven of its top aviation personnel to a Rolls-Royce training school in Montreal to be instructed in operation and maintenance of turboprop engines.

• **Simmonds Accessories, Inc.,** has announced a new Liquid Level Sensing System said to provide reliable, accurate, and trouble-free indication of liquid level. Characteristics include resistance to shock, vibration, and corrosion; no moving parts; a.c. or d.c. powered; low power consumption; operation from

Pan American World Airways, Inc., plans to build the air terminal shown for $8 million at New York International Airport in 1958. The design calls for a cantilever roof 4 acres in area to cover passengers and aircraft. The air line says the new terminal will eliminate many inconveniences encountered in existing terminals.

New SPS High-Temperature Fasteners Have 170,000 psi Tensile Strength at 900°F

Hi Tm 9 bolt and nut developed by SPS research help solve Mach 3-4 fastening problems



NEW EWB Tm 9 BOLT is made of a hot work die steel (VascoJet 1000); has 220,000 psi tensile at room temperature, 170,000 psi at 900°F. Companion Flexloc locknut—EWN Tm 9—is made of AMS 6304 material; has ample strength to utilize the full tensile values of the bolt at all temperatures up to 900°F.

In response to the aircraft industry's request for a fastener with high strength and stability at Mach 3-4 skin temperatures, SPS has developed a 12-point external wrenching bolt with 170,000 psi minimum tensile at 900°F. Classified as EWB Tm 9, this remarkable new bolt—made of a 5% chrome die steel—is actually stronger at 900°F than most other high-strength bolts at room temperature. And it retains its high tensile strength even after long exposure to heat. Other properties, such as shear, fatigue and stress rupture, are also superior—both at room and elevated temperatures.

To match the EWB Tm 9 bolt, SPS has produced a new external wrenching Flexloc self-locking nut—EWN Tm 9. Made of AMS 6304, it utilizes the full mechanical properties of the EWB Tm 9 bolt at all temperatures up to 900°F. Both units—bolt and locknut—are finished in a diffused cadmium-nickel plate that resists the accelerated oxidation effects of high temperatures and corrosion at room temperature.

With their high strength-to-weight ratio and ability to withstand the deteriorating effects of heat, the EWB Tm 9 bolt and companion locknut give the designer an important new tool with which to solve the fastening problems presented by high-speed, high-temperature flight. Hi Tm 9 fasteners are available as 12-point external wrenching tension bolts and locknuts in diameters from ¼ to 1½ in. The same material and processing procedures can also be applied to shear bolts and other special applications. SPS Aircraft Products Division engineers are ready to work with you in applying these new fasteners to your specific high-temperature problems.

MIN. TENSILE STRENGTH OF EWB Tm 9 VS. STAINLESS AND ALLOY STEEL BOLTS

	At Room Temp. (F)	At 800°F	At 900°F
EWB Tm 9 (VascoJet 1000)	220,000	190,000	170,000
AMS 5616 (stainless steel)	145,000	105,000	95-100,000
AMS 6304 (alloy steel)	145,000	123,000	110-120,000

EWB Tm 9 BOLT has 50-70% greater tensile strength at 900°F than stainless and alloy steel fasteners currently used at this temperature. Above data are for *bolts*, not material specimens.

MECHANICAL PROPERTIES OF THE EWB Tm 9 BOLT

Properties	At Room Temp. (F)	Room Temp. After 100 Hr. Soak at 900°F	At 900°F
Ultimate tensile, psi minimum	220,000	220,000	170,000
Yield strength, psi minimum	185,000	185,000	140,000
Elongation in 4 diam., % minimum (specimen)	10	10	16
Reduction of area, % minimum (specimen)	35	35	50
Shear strength, psi minimum	140,000	140,000	100,000
Stress rupture, psi for 100 hr. life	.....	.....	130,000
Fatigue strength, psi /8,000,000c/10% preload	80,000	60,000	80,000
Impact strength, ft.-lb. (Charpy)	18	18	23

AT 900°F THE EWB Tm 9 BOLT offers mechanical properties exceeding those of an MS 20004 Series bolt at room temperature. Equally significant in this thermal barrier breakthrough, it retains superior properties even after long exposure to high temperatures.

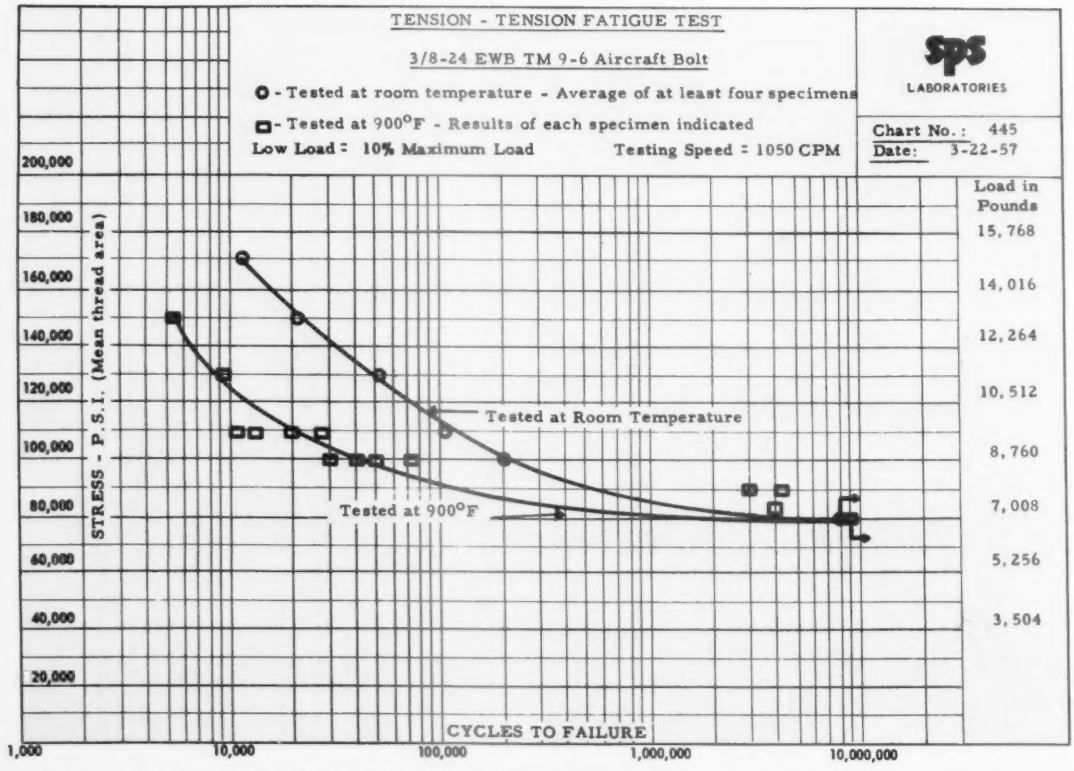
BREAKING THE TEMPERATURE BARRIER. An EWB Tm 9 bolt is positioned for testing on a tensile machine equipped with a furnace that is accurate within ±2°F up to 2000°F. At-temperature research data on the EWB Tm 9 are the most extensive ever assembled for a production fastener. They include the first fatigue and shear compilations for bolts under heat.

Hardware for High-Speed Airframes

The SPS crash program on a new high-strength, high-temperature fastener began late in 1955 following the aircraft industry's demand for hardware for 800°F skin temperature. A year later the first EWB Tm 9 bolt was produced. This was possible because of SPS's extensive research and test facilities built up over the years, and the largest in the industry.

With high-strength fastener fabrication techniques well in hand after development of the EWB 18 bolt (180,000 psi) and the EWB 22 bolt (220,000 psi), the biggest problem was to find an alloy of the desired mechanical properties at elevated temperatures. Many materials were subjected to exhaustive testing. Finally VascoJet 1000, a 5% chromium hot work die steel made by Vanadium-Alloys Steel Co., was chosen. Its stability and strength at high temperatures largely determined selection of it.

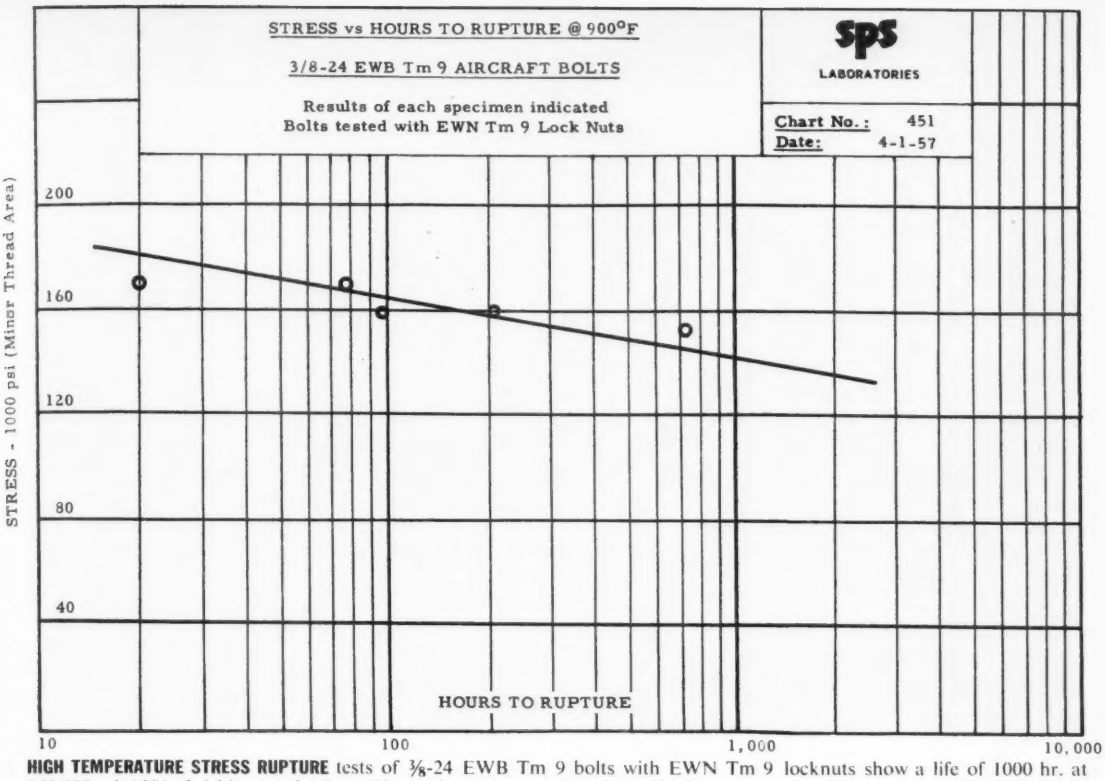
The other major problem was plating. Cadmium melts at just above 600°F and diffuses into the bolt metal, causing embrittlement. Research turned up an existing plating technique—AMS 2416—that proved to be the solution. This finish is applied as separate layers of cadmium and nickel. After plating, the parts are heated to 630°F, at which temperature the two metals diffuse into an alloy that successfully resists the aggravated oxidation and corrosion caused by high temperatures.



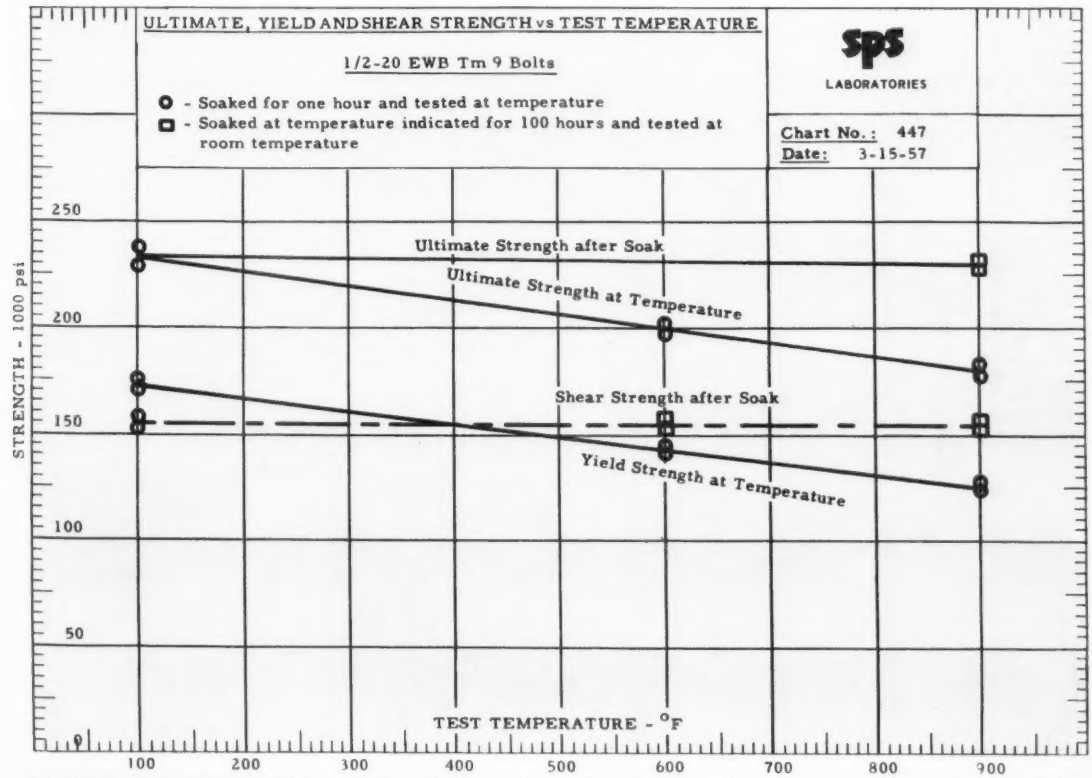
TENSION-TENSION FATIGUE TESTS of ⅜-24 EWB Tm 9 bolts showing values obtained when tested at room temperature and 900°F. It should be noted that the fatigue strength at 8,000,000 cycles is approximately the same at both test temperatures.

STRESS - 1000 psi (Minor Thread Area)

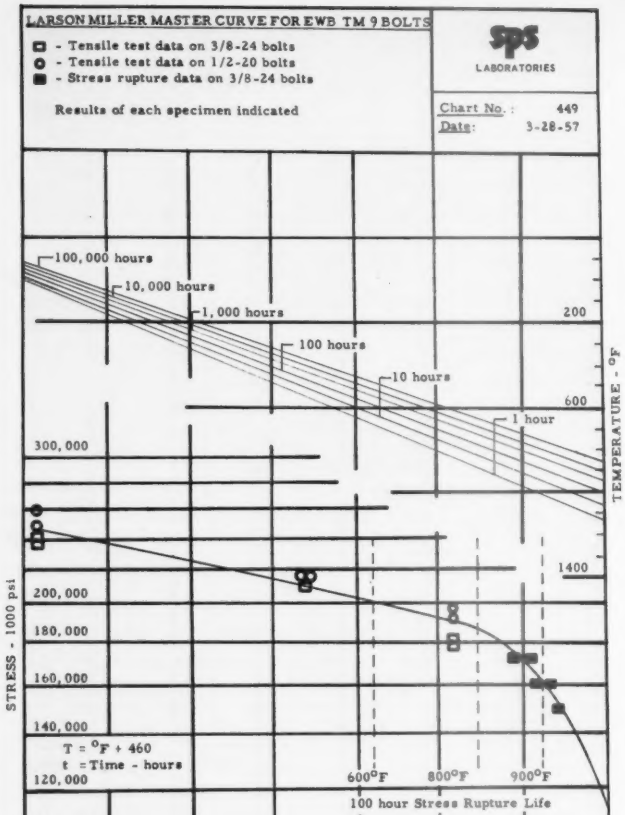
STRENGTH - 1000 psi



HIGH TEMPERATURE STRESS RUPTURE tests of ⅜-24 EWB Tm 9 bolts with EWN Tm 9 locknuts show a life of 1000 hr. at 140,000 psi (95% of yield strength). Long life results from a combination of high strength material, new fabricating techniques, and advanced design, including SPS Hi R thread form. Hi R thread has a greater root radius than any other standard form; this reduces stress concentration at the weakest point of the bolt, and thus increases fatigue strength and stress rupture life.

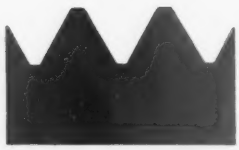


½-20 EWB Tm 9 BOLTS show high values for ultimate, yield and shear both at 900°F. and at room temperature after 100 hr. soak. Because they retain superior mechanical properties even after long exposure to elevated temperatures, the new EWB Tm 9 bolts offer airframe designers a solution to the problem of fastener deterioration at high Mach numbers.

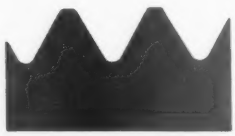


FIRST LARSON-MILLER STRESS RUPTURE CURVES for a threaded fastener were plotted in SPS laboratories with data obtained from high-temperature tensile tests and stress rupture tests run on the EWB Tm 9 bolt. From these curves the stress rupture point in any given amount of time can be calculated. For example, for a life of 10,000 hr. at 900°F, it is shown that the EWB Tm 9 bolt will withstand a stress of 120,000 psi.

How SPS Hi R Thread Form Increases Fatigue Life

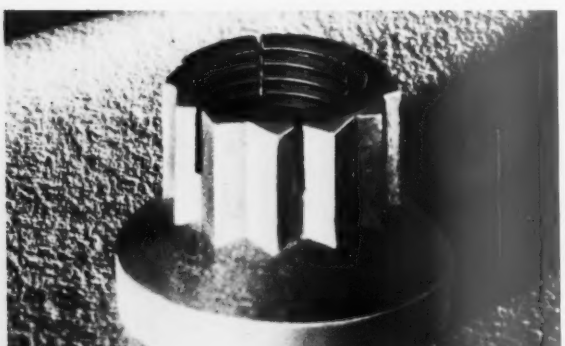


Unretouched Comparator Photograph of MIL-S-7742 thread. Flat thread roots with small radii cause points of high stress concentration which reduce fatigue life.



MIL-S-7742, MIL-B-7838a Threads. Larger (.0065 in.), more uniform radius reduces stress concentration, increases fatigue life.

Hi R Thread Form. Increased root radius (.009 in.) reduces stress concentrations still further for greater increase in fatigue .resistance. Thread assembles with standard tapped holes and nuts.



EWN Tm 9 Flexloc Locknut Develops Full Strength of the EWB Tm 9 Bolt

The EWN Tm 9 self-locking nut is made of AMS 6304 material. It has ample strength to utilize the full tensile values of the EWB Tm 9 bolt at all temperatures up to 900°F. Configuration of the EWN Tm 9 locknut distributes the load over more metal threads than in conventional fasteners. Its design helps reduce stress concentrations to a minimum. Like its companion bolt, the EWN Tm 9 locknut is plated with a diffused cadmium-nickel capable of resisting the destructive effects of temperatures up to 1000°F.

For more information on SPS Tm 9 fasteners, write Aircraft Products Division, STANDARD PRESSED STEEL CO., Jenkintown 58, Pa.

STANDARD PRESSED STEEL CO.

AIRCRAFT PRODUCTS DIVISION

SPS

JENKINTOWN PENNSYLVANIA

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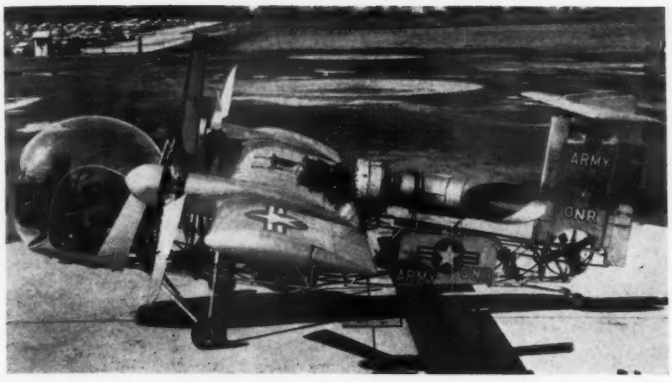

Vertol Aircraft Corporation's turbine-powered VTOL research aircraft, funded by the Army and developed in cooperation with the Office of Naval Research, has begun functional testing. The firm reports it is the first tilt-wing VTOL ever to be readied for testing. Designated the Vertol 76, it is powered by a Lycoming T-53 gas-turbine engine.

−67° to 167°F.; and use in military aircraft fuel, hydraulic fluid, aircraft gas-turbine lubricating oil, Skydrol, jet-engine lubricating oil, aircraft engine lubricating oil, and other hydrocarbon liquids.

• **Sperry Gyroscope Company Division of Sperry Rand Corporation**. . .AN/SPQ-5 super-radars developed by the firm are in service with the Navy for long-range, high-altitude missile guidance. . . .The firm has published a new booklet covering design principles, operation, and application of Sperry's Integrated Instrument System for pilots of air-line and executive aircraft.

• **Union Carbide Corporation** is the new name for Union Carbide and Carbon Corporation. The names of three divisions also have been changed: Linde Air Products Company becomes Linde Company, Carbide and Carbon Chemicals becomes Union Carbide Chemicals Company, and Carbide and Carbon Realty is Union Carbide Realty Company.

• **United Air Lines, Inc.**, and American Airlines, Inc., have begun operating a mutual teletype exchange at Chicago.

• **Vertol Aircraft Corporation** is offering three versions of its H-21 military helicopter for commercial sale. Designated Vertol 44, a cargo version, air-line type, and executive version are being offered. . . . The Vertol 76, a tilt-wing VTOL research aircraft, is marked by these characteristics: wing and two counter-revolving rotor-propellers tilt as a unit through a 90° arch for vertical take-off and landing or level flight, two ducted fans in tail to control yaw and pitch in a hovering regime, and gas-turbine engine aft of the cockpit and atop a tubular fuselage structure.

• **Western Gear Corporation**. . .Electro Products Division has announced design and availability of a new 2.5-hp., 400-cycle, 200-volt, three-phase aircraft brake motor said to weigh less than 10 lbs. with a 5-hp. peak. The firm says its rated speed is 11,000 r.p.m. and that it has a starting torque of 715 oz.in. Designation is Model IH42YK5B.

• **Westinghouse Electric Corporation** is using gamma rays from radioactive cobalt to detect and control the level of molten titanium in a new cold hearth arc furnace for preparing purified titanium metal. . . . A new aircraft electrical system composed principally of four air-cooled brushless generators will supply power for pumps, blowers, lights, air conditioning, food warmers, radar, radio, and other equipment in Boeing 707's. . . .The firm has announced plans to build a nuclear materials testing reactor, said to be industry's first. . . .A new and lighter molded aircraft current transformer for metering and relaying on aircraft electrical systems is available. . . .A new booklet, *Westinghouse Copper-Clad Micarta Plastic Laminate for Printed Circuits* (B-6577), is available at P.O. Box 2099, Pittsburgh 30, Pa.

IAS SECTIONS

Perkins on USAF R&D

Baltimore, Washington, and Hagerstown Sections

Air Force Chief Scientist Courtland D. Perkins explained "Ultimate Objectives of Air Force Research and Development" to 170 members and guests of the Baltimore, Washington, and Hagerstown Sections on April 16.

Dr. Perkins said research and development objectives should be geared toward producing the greatest possible combat capability with respect to our anticipated operational environment. Elements of this environment lead us into the offensive and defensive weapon systems with which we are all becoming quite familiar.

On the offensive side we are looking for faster reaction time, increased range and accuracy trade-offs, less vulnerability of the launching base as well as over the target, and the very minimum of launch time. We must also maximize the reliability of these systems to ensure that when they are launched in a short time they will, in fact, arrive at the target.

On the defensive side, our weapon sys-

Baltimore, Washington, and Hagerstown Sections heard Courtland D. Perkins, USAF Chief Scientist, *(lower right)* speak on April 16. Others at the meeting were *(seated left to right)* Louis Fahnestock, Director, Projects Administration, Fairchild; T. L. K. Smull, Chairman, Washington Section; John Attinello, Assistant Chief of Research, Fairchild; and Dr. Perkins. Standing *left to right* are Claude S. Huber, Chairman, Hagerstown Section; Walter Tydon, Chief Engineer, Fairchild; Abraham Hyatt, Chief Scientist, BuAer; and Richard W. Sanford, Chairman, Baltimore Section.

FOR
Automatic Control
OF TEST LIMITS
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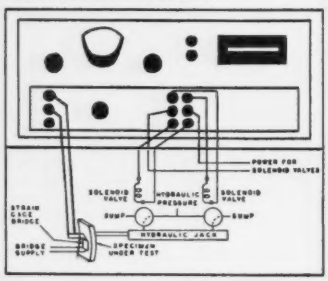

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tems must be geared to the new operational environment with great care. In this area, alert status and rapid reaction time are the major factors. We are tending to hand over the close-in defense of our country to the radars, computers, and guided missiles. The system is tremendously complex and will require an order of magnitude improvement in reliability of many components before it can be considered completely effective. He said that the development of longer ranged radars and defensive missiles of high reliability and effectiveness are absolute musts for our development program.

Dr. Perkins compared the Intercontinental Ballistic mission experiments in Florida with German V-2 experiments. He said that the Air Force should expect a high percentage of failures during initial tests.

One of the bigger problems facing the Air Force is how to interrelate manned and unmanned weapons into a single effective defense force. Airplanes have greater accuracy and are better for selective targets, but missiles have faster reaction time, take less time to launch, are more easily dispersed, and are less vulnerable.

He cited lack of reliability as the main problem with missiles. "We must learn to treat reliability like any other performance factor," he said, and "in electronics, the reliability is notoriously low."

The Air Force's big need is for "simplicity in design"—to reduce the number of working parts in missiles and allow greater tolerance factors. The weapons system will be operated by average men, and simplicity of design and operation "should be given first consideration," he said.

R. W. BRADHAM, *Secretary*
Hagerstown Section

Chicago Section

The "new look" in aircraft carriers was described by Capt. Lamar P. Carver, USN, Commanding Officer, Glenview, Ill., Naval Air Station, before 110 members and guests who also visited one of the Navy's hangars on April 10.

"We have always been ahead of the Russians in Naval aviation and will always be ahead," he said. The Joint Chiefs of Staff have determined that six carriers must operate throughout the world at all times. To accomplish this, 15 carriers will be needed in order to maintain normal rotation and ship repair schedules.

Speaking on "Modern-Day Carrier Operations," Captain Carver explained some of the improvements incorporated into the U.S.S. "Bon Homme Richard" which he commanded. The ship has an angled deck, hurricane bow, steam catapult, mirror landing system, and heavier protection under the waterline. It can handle all Navy aircraft except the A-3D. He said the angled deck and mirror system have reduced landing accidents by 75 per cent and expedited handling of aircraft.

Turning into the wind to launch aircraft is no longer necessary with the new steam catapult. A 70,000-lb. aircraft may be launched at 115 knots without any wind, and some aircraft may be launched cross-

Captain Lamar P. Carver, USN

wind or even downwind with this catapult, he said. It also allows the carrier to steam to its destination by reducing off-course time.

Captain Carver said all carriers of the Essex Class, to which the "Bon Homme Richard" belongs, will be reclassified for antisub work only. But the real step forward will come with the commissioning of the first nuclear-powered carrier, whose obvious advantages are increased range and endurance at high speed. Less obvious is the advantage in space. More aviation fuel will be carried in bunkers which once held fuel for the ship.

A film, *Operation One Grand*, showing the F-8U Crusader creating a speed record, was shown at the end of the meeting.

R. F. HUNTER, *Secretary*

Dayton Section

Albert E. Lombard, Jr., Director of Research for McDonnell Aircraft Corporation, spoke on "Research Objectives" at the April 18 meeting.

Dr. Lombard said that the McDonnell Research Division is on the same level as the firm's Aircraft, Missile, and Helicopter Divisions. McDonnell also subcontracts some of its research, making it possible to get a broader viewpoint.

Research which is used by engineers in 5 years is considered long range. He also was of the opinion that some practical work must be done by a research organization in industry.

After the talk a film, *The F-101 Voodoo*, was shown.

▶ Some methods of "NACA Crash Survival Research" were outlined by G. Merritt Preston, Chief, Flight Research Branch, NACA Lewis Flight Propulsion Laboratory, at the March 21 dinner meeting.

He discussed research on the start and development of crash-fires in jet and reciprocating engines. Mention was made of impact loads found in crashes of light planes and fighter, cargo, and passenger planes.

He told of investigating the manner in which combustibles spread, the union of combustibles and ignition sources, and the formation of ignition sources during a

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crash. Investigation along these lines has led to a method for reducing the likelihood of fire after a crash.

The magnitude of crash decelerations that might be expected in the longitudinal, vertical, and lateral axes was indicated during research on a variety of aircraft.

W. E. STANGER, *Secretary*

Hampton Roads Section

The B-58 program to date was reviewed by C. L. Seacord, Jr., Senior Aerophysics Group Engineer in charge of Stability and Automatic Control Groups, Convair, Fort Worth, A Division of General Dynamics Corporation.

Keeping within security limits, he described problems of stability, automatic control, area-rule application, and weapons system management. He said the Fort Worth plant is particularly proud of what it has achieved with regard to a new approach to weapons system management. Convair is responsible for each of the components incorporated in the airplane. Mr. Seacord said that this has resulted in a much more closely integrated airplane design and a shortening of lead time compared to that previously possible.

He showed sound movies of taxiing tests and first flights and slides of various ground positions of the B-58.

RICHARD T. WHITCOMB
Secretary

Los Angeles Section

Dan A. Kimball, President, Aerojet-General Corporation, outlined "Current Projects in Rocketry" at the April 18 dinner meeting.

An era in which rocket-powered planes will take passengers across the nation in an hour will dawn "before many years," he said. "I know that to prognosticate about the future is to bring the wrath of the gods—particularly the conservative gods—down upon your head. Nevertheless, I believe that progress is made only when your neck is out," Mr. Kimball said.

He based these observations on the current work of engineers and scientists which, he said, indicates a future in which Project Vanguard and the Intercontinental Ballistic Missile "will look like the horse and buggy."

A. J. CARAH, *Secretary*

IGY Program

Rocky Mountain Section

Leonard Arnowitz discussed the IGY program before 240 members and guests of the Section and the American Rocket Society at a joint dinner meeting in Denver, March 19. Mr. Arnowitz is Assistant Project Engineer, Project Vanguard Flight Plan Control.

He outlined principal objectives as (1) to investigate all geological and atmospheric conditions existing on the earth and (2) to evaluate changes that are taking place.

He said that one of the more practical aspects of this study is to determine basic causes of climatic changes and to improve methods of long-range weather forecasting.

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Representing General Dynamics Corp. at the San Diego Section's joint dinner meeting with ASME on April 9 were *(left)* ASME Section Chairman R. H. Meleney, Long Range Planning Group, Convair Astronautics Division; guest chairman C. L. Critchfield, Convair Director of Scientific Research; guest speaker L. B. Richardson, corporate Vice-President—Engineering; and IAS Section Chairman H. C. Matteson, Convair Senior Aerodynamics Group Engineer.

Various types of radiation incident on the earth from outer space—all forms of solar radiation—will be studied in relation to their effect on living matter, radio transmission, and weather.

Mr. Arnowitz drew a word-picture of the program from its beginning and discussed forthcoming launching plans. Slides showing the configuration of the launching vehicle and ground-handling equipment also were employed.

Turning to data collection, he said that the various types of radiation will be measured and information transmitted to ground stations by means of the Minitrac Telemetering System. Radio triangulation will establish the trajectory of the satellite before optical tracking takes over. Electronic computers will furnish information about orbital changes.

Extensive data on orbit characteristics will be taken to determine atmospheric composition at extreme altitudes. Scientists also hope to determine type and density of matter such as meteors, meteoric dust, and atoms and ions in space and to gain insights into the character of electrical and magnetic fields about the earth.

Mr. Arnowitz supplemented his discussion with a film, *Horizons Unlimited*, about the Martin Viking.

A. W. GILMORE, *Secretary*

San Antonio Section

A program centered on "Aeronautical Research Activity at Southwest Research Institute" was presented by three members of Southwest before 100 members and guests on April 17.

Martin Goland, Vice-President of Southwest, was Chairman of the panel. Speakers and their subjects were T. P. Epperson, "Research in Aeroelasticity and Dynamics"; C. H. Yuill, "Research in Crash-Fire Protection"; and Al Hundere, "Research in Aircraft Fuel and Lubricants."

Distinguished guests included Major Gen. T. C. Odom, USAF, Commander, San Antonio Air Material Area; B. F. Coggan, Vice-President and Manager, Convair, San Diego; and Major Gen. Clements McMullen, USAF (Ret.), a charter member of the IAS.

H. Norman Abramson, Vice-Chairman of the Section, was Program Chairman.

I. W. DRAPER, JR., *Secretary*

San Diego Section

Rear Adm. L. B. Richardson, USN (Ret.), discussed "Factors Influencing the Developments of Large Corporations" at the April 9 meeting. Admiral Richardson is Senior Vice-President—Engineering, General Dynamics Corporation, a Fellow and former President of the IAS.

Centering his talk on General Dynamics, he said that the history of the firm began with the founding in 1880 of the Electro Dynamic Corporation. Since that time it has grown to 87,000 employees in five divisions: Electro Dynamic, Electric Boat, Convair, Stromberg-Carlson, General Atomic, and its Canadian subsidiary, Canadair.

The name General Dynamics was created in 1952, he said, because the name "dynamics" encompasses all of the corporation's activities—hydrodynamics, thermodynamics, aerodynamics, electrodynamics, astrodynamics, and what might be termed "nucleodynamics."

Admiral Richardson said the firm's purpose is "the profitable translation of basic forces of nature into useful work under the sea, on the sea, on land, in the air, and in the space beyond the earth's atmosphere." To accomplish this purpose, the firm will continue to grow in a logical and well-directed manner into those fields which are complimentary and supplementary to those in which it is now engaged.

He said a large measure of past success is due to the fact that General Dynamics is engineer-oriented. Its future growth depends upon the success of present and future products, themselves dependent upon the creative abilities of its engineers and scientists.

A new sound system donated to the IAS by Stromberg-Carlson Division was used for the first time at this meeting. New microphones, amplifier, and speaker system were installed by members under supervision of the division's Chief Engineer. The Section Chairman paid special thanks to General Dynamics Corporation for the gift.

▶ Ludwig Roth of Solar Aircraft Company spoke on "Teamwork in Guided Missile Development" at the March 19 meeting.

Mr. Roth is Executive Assistant at Solar and former Chief of Preliminary Design at the Guided Missile Center, Peenemuende, Germany, and Assistant Director, Guided Missile Development Division, Redstone Arsenal.

He declared, "Important as they are, inventions, discoveries, etc., are only the beginning. Developing and finally producing are actually sometimes more difficult and frustrating as most of you well know. Here, the importance of teamwork is growing immensely. Sure, you might achieve some results without it, but we are talking about optimum results, achieving tomorrow what is still a dream today."

▶ Nearly 120 members were guests of the 11th Naval District on March 11 for a 1-day cruise aboard the aircraft carrier U.S.S. "Essex." Los Angeles Section joined this Section for the trip.

From 7 a.m. to 4:30 p.m. the two Sections observed carrier operations. Highlights included flights of F4D, F9F8, and AD7 aircraft from the canted deck and a demonstration of the mirror system for landings, a replacement for Landing Signal Officers.

▶ "Combustion Research" was discussed by Abraham Berlad before a joint meeting with the American Rocket Society on March 7. Dr. Berlad is Senior Staff Scientist in Combustion at the Convair Scientific Research Laboratory.

He outlined several fuel and flame problems which need more fundamental research. Basic research in flames and fuels was related to today's propulsion development problems.

He described high impulse propellants and uses of free radicals as superfuel in detail. He concluded with a description of combustion research at Convair.

P. E. CULBERTSON
Corresponding Secretary

Building Hotshot

Tullahoma Section

Ira P. Jones ("F" Branch), Gas Dynamics Facility, AEDC, spoke May 1 on the development and status of Hotshot, an intermittent wind tunnel producing test section velocities in excess of 10,000 ft./sec. and stagnation temperatures in excess of 15,000°F. Some 30 members attended the dinner meeting.

Hotshot development began as an attempt to improve the driver component of the shock tube. Mechanical difficulties with an adiabatic compressor turned the work to electrical techniques which led to

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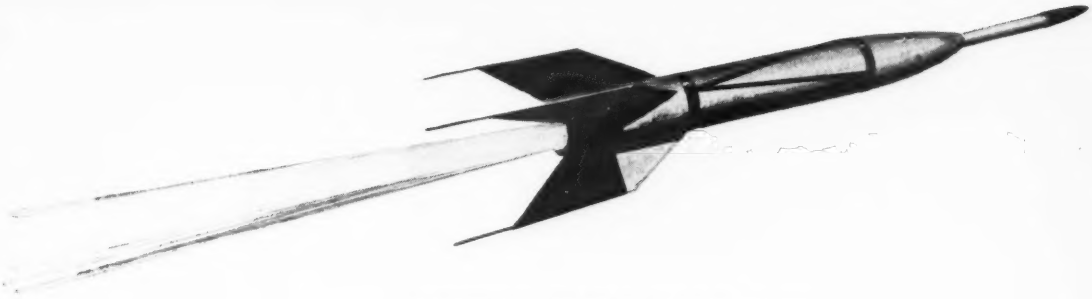

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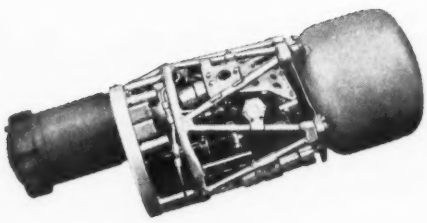

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building a storage capacitor to heat the air in a reservoir by direct electric arc discharge.

As a result of success with this unit, a one million joule-1/8 Farad capacitor was built to power Hotshot. During construction it was found that the air could be expanded directly from the reservoir through the nozzle in a hypervelocity flow thus eliminating the shock tube. Hotshot was subsequently converted from a sustained-discharge, electrically driven shock tube to a spark-heated hypersonic blowdown tunnel. Information gathered in building this tunnel is being used to build a larger tunnel which is awaiting a permanent power source.

Mr. Jones said Hotshot resembles a blowdown tunnel in that it has a high-pressure reservoir, a Laval conical nozzle, a circular test section, and a vacuum tank. Run times are 20 to 30 millisec., an order of magnitude longer than shock tubes.

The main operational problem initially was the containment of air in the reservoir at many thousands of psi pressure and many thousands of degrees temperature. A reliable arc chamber design has been evolved for pressures now being used.

Instrumentation is difficult because of the short times involved and the large magnetic fields due to arc discharge. A commercial variable-reluctance, low-impedance pressure transducer proved satisfactory for measuring model and test section pressures over a range of 100 microns of Mg to 5 psi. A heat-transfer gage based on the variable reluctance principle measures heat transfer.

Mr. Jones said Hotshot is used for development testing. When the larger model Hotshot II is completed, the other can be used for studying more basic problems.

GENE HULL, *Secretary*

Tulsa Section

Advantages of "The Aerodyne" over conventional aircraft were explained by Alexander M. Lippisch at the April 8 meeting. Dr. Lippisch is Director of Aeronautical Research, Collins Radio Company.

He said that today's aircraft are essentially still powered gliders, and, as such, they require prepared landing areas of increasing size as speeds go higher. In this country the requirement presents no problem, he said, but many areas in the world do not possess adequate fields for current aircraft.

Current power plants with their favorable power ratios make possible the operation of craft such as the Aerodyne. Among the inherent advantages is its ability to take off and land vertically and hover without the complicated rotor arrangements of the helicopter, relatively high forward speeds without complicated converting mechanisms, and more efficient structural utilization.

Dr. Lippisch's talk was accompanied by slides illustrating the theory of the Aerodyne and by a movie showing flight tests of model configurations.

C. K. BARTON
Recording Secretary

Wichita Section

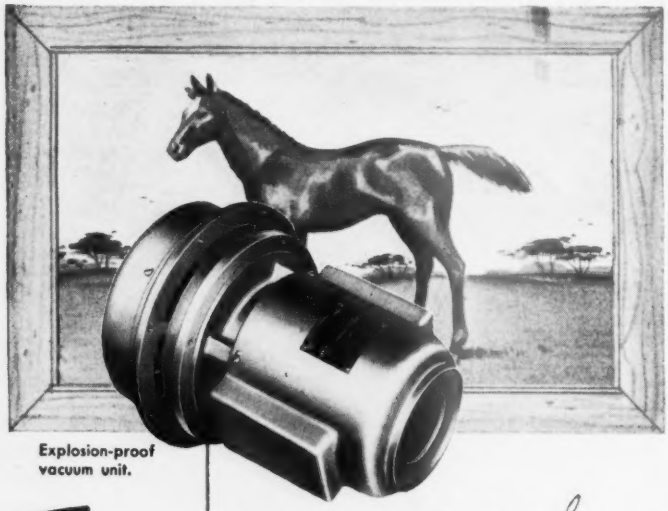
"The Vickers Viscount" story was told by J. B. Franklin before 70 members and guests at the April 3 meeting, which also saw the introduction of new officers for 1957. Mr. Franklin is Vice-President, Operations and Maintenance, Capital Airlines.

New officers are Preston Dickson, Chairman; Glen McCormick, Vice-Chairman; Howard Smith, Secretary; and Don Ahrens, Treasurer.

Mr. Franklin centered his talk on Viscount operations and maintenance. Capital, which has 60 Viscounts (15 more on order), wanted an airplane with passenger appeal and one that would be economical to operate. A survey of manufacturers showed Vickers Incorporated could produce an air liner to meet Capital's short-haul needs and one that would be available soon.

Before taking delivery a training program was instituted, using ground trainers to simulate all flight conditions except braking and landing roll. Special classes in fuel management control were set up, and mechanics were sent to Vickers to learn special maintenance handling.

Mr. Franklin said the Viscount had the best customer appeal of any airplane used by Capital but that some problems did arise after it was put into service. A new air-conditioning system was installed for better passenger comfort and an air stair was installed to reduce loading and unloading time between flights.



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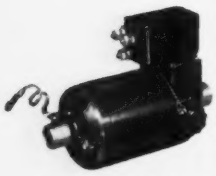

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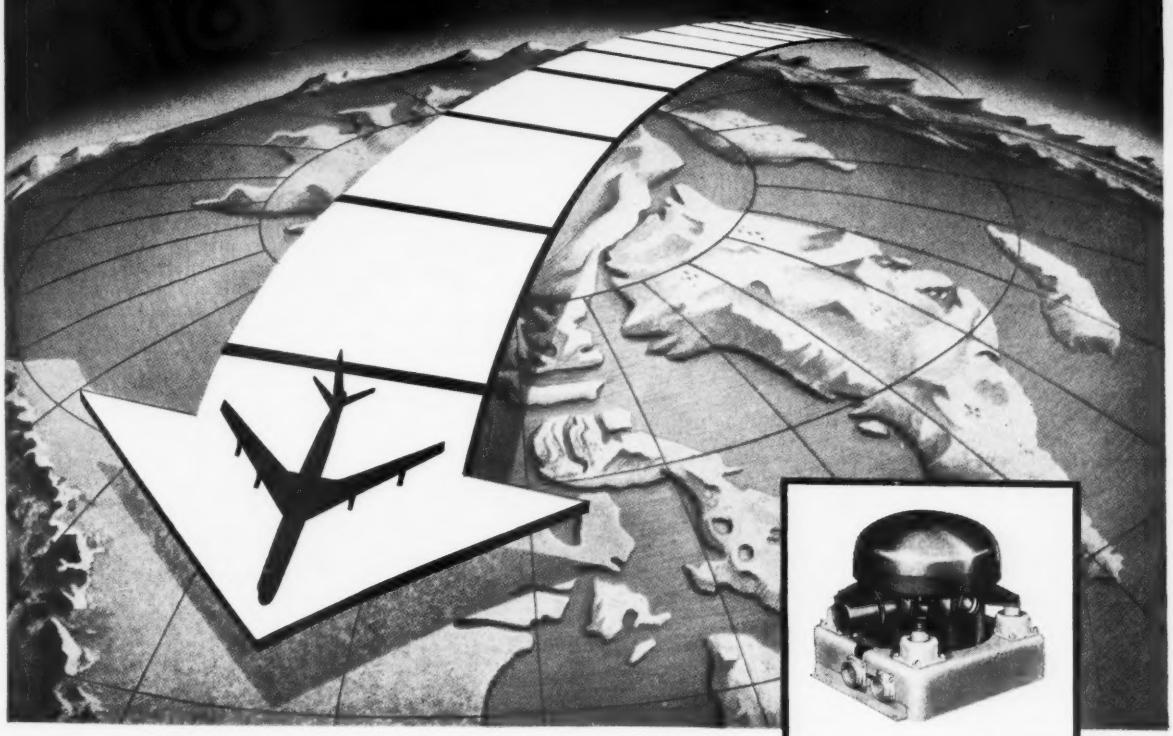

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Designed especially for navigation of long-range, high-speed aircraft, the C-11 employs new design principles to achieve this unprecedented accuracy. At latitudes up to 65° the system provides precise heading indication in its normal function as a slaved directional gyro. At higher latitudes, where magnetic compasses are unreliable, the gyro can be unslaved to operate freely and still provide less than ½° per hour random drift rate.

The all-transistorized C-11 system is compatible with all large aircraft, military and commercial. Write our Aeronautical Equipment Division for further details on this notable Sperry contribution to safer, more accurate long-range navigation. *T. M. REG. U. S. PAT. OFF.

Major Features of the C-11

ACCURACY— *Direct coupling of gyro and master indicator eliminate the synchro errors common in repeater-type systems.*

CONTROLLED LATITUDE CORRECTION *Automatic compensation for apparent drift due to earth's rotation. This corrective action is achieved in slaved or unslaved condition.*

ENVIRONMENT RANGE— *Maintains accuracy at temperatures from -54°C to 71°C, and at altitudes up to 70,000 feet.*

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He said the break-even point using the Viscount is about 50 per cent on a 350-mile trip, 40 per cent for 600 miles, and less than 40 per cent for 800-mile flights. Dart engine reliability has been the best of any engine used by Capital.

Comet air liners will join the Viscount fleet on some of the longer routes in the near future, he said. The Comet was chosen for the same reasons as the Viscount —availability, economy, and passenger appeal. The Comet also will have a relatively low cruising altitude and thus fit into short-haul operation.

The audience engaged Mr. Franklin in a question and answer session after his talk.

E. J. SULLIVAN, *Secretary*

STUDENT BRANCHES

Georgia Institute of Technology

George Houseman, Assistant Chief Research Engineer, United Aircraft Corporation, spoke on "Current Trends in Propulsion Research" at the April 16 meeting.

Mr. Houseman compared air-breathing power plants with rockets and stressed the importance of power-plant consideration to the aeronautical engineer. He also discussed some of the effects that the trend toward higher speeds and altitudes are expected to have on future propulsion systems.

Mr. Houseman used slides to explain limits of air-breathing power plants and to show probable power-plant configurations and aircraft designs of the years to come. He emphasized the importance of internal aerodynamics over external aerodynamics.

▶ A new slate of officers was elected at the April 15 meeting. They are: Chairman, Lester R. Smith; Vice-Chairman, James Blahnik; Secretary, Roy V. Harris, Jr.; and Treasurer, Charles E. Johnson.

ROY V. HARRIS, JR., *Secretary*

Iowa State College

Roy Bohner spoke on conversion of a Ryan Navion to a remote-controlled drone at the April 24 meeting. Mr. Bohner is coordinator of the classified missile division, Temco Aircraft Company.

He said the drone (QL-17) was designed to perform television reconnaissance for the Army Signal Corps. He also described flight controls and problems encountered in controlling flight.

▶ Paul Peterson, of the Theoretical and Applied Mechanics Department, spoke on the $1,000 analog computer he built from a Heathkit, at the April 10 meeting.

Dr. Peterson began by describing the computer and then explained some of the theory and underlying principles. He demonstrated the solution of several problems using the computer.

JOHN ANDERSON, *Secretary*

Kent State University

Plans for a spring banquet to be held in conjunction with the pre-engineering section of the Industrial Arts Department were completed at the April 9 meeting.

A representative from North American Aviation, Inc., scheduled to speak was unable to attend this meeting. Plans were made to have him appear at a later date.

▶ Branch member Thomas Kinsel read his thesis on "Compressor Surge and Stall" at the March 5 meeting.

▶ Members attended a joint meeting of the IAS Cleveland-Akron Section and the American Rocket Society for a lecture on "The Psychological Problems of Space Flight" on February 14. A movie showing the effects of space flight on monkeys and mice augmented the lecture.

▶ David Kemp was elected Secretary of the Branch at a special election on February 12. A movie on *Aircraft Landing Techniques* was shown.

The Pennsylvania State University

Five student papers scheduled to be given at the Middle-Atlantic Conference were presented at the April 29 meeting to determine Branch winners.

Some 30 students and instructors listened to the following papers: "Base Pressure Drag With and Without a Jet at Low Speed" by Frederick K. Evans and Raymond F. Garlin, Jr.; "Variation of Rolling Moment Coefficient With Sweepback and Aspect Ratio" by Richard Borbrow; "Ground Effect on the Lift of Straight and Sweptback Wings" by Franklin W. Barr; "Boundary Conditions for the Post Buckling Behavior of Flat Plates" by Charles A. Lindle, Jr., and Ken A. McClynonds; and "The Case for the Supersonic Propeller" by Clarence A. Fry.

John A. Fox, faculty adviser, and Kenneth P. Kerr, senior aeronautical engineering student, described their trip to Fort Worth where Mr. Kerr gave a paper on "Flow in Curved Ducts" at the Southwest Region Conference.

Plans for a banquet at which award winners are scheduled to be announced were discussed.

JERRY C. DUNLAP, *Secretary*

Polytechnic Institute of Brooklyn

Robert S. Levy spoke on "Structural Analysis and Design" at the April 30 meeting. Dr. Levy is Design Specialist, Republic Aviation Corporation.

He gave students an insight into the problems associated with the design of a suitable wing fuselage juncture by drawing from his experience on the F-105 Thunderchief.

New manufacturing methods had to be found to form the required joints and fittings to provide room for the aircraft's internal equipment and to maintain adequate structural strength, he said. This caused material failure problems and, as a result, required new structural testing methods.

▶ A delegation of members visited Cornell University Aeronautical Laboratory during Easter recess. They learned that work is carried on there in such diverse fields as aero- and thermodynamics; aircraft, missile, and helicopter design and testing; atmospheric physics; structural and electronic research; transportation safety; weapons engineering; and industrial research. The function and facilities of each section visited was explained by department heads.

▶ Branch officers elected at the April 9 meeting were Ira Cohen, Chairman; Tom Lardner, Vice-Chairman; Robert Stebert, Treasurer; Donald McKenzie, Corresponding Secretary; and Paul Shaff, Recording Secretary. These are officers for the 1957–1958 school year.

▶ *Aerothermodynamics*, a Convair lecture series film narrated by Dr. Theodore von Kármán, was shown on March 26. The film depicted this new and expanding field as an outgrowth of basic aerodynamic and thermodynamic relations. At the same time, it accounted for the real gas effects and dissociation phenomena occurring at high speeds and altitudes.

▶ Macon Epps spoke on "Weight—The Fourth Vector" before 40 members visiting Grumman Aircraft Engineering Corporation's Bethpage plant on March 13. Mr. Epps is Chief Technical Engineer.

His talk centered on the importance of continual and careful control in designing supersonic aircraft. After a brief question and answer period members examined manufacturing facilities, the static test laboratory, and the low-speed wind tunnel.

The group was provided with bus transportation to the Peconic River plant. A live demonstration of the F11F-1 armament and power plant was seen before a tour of the final assembly line where Tiger and Cougar aircraft are finished side-by-side. The visit ended with a low-altitude, high-speed fly by.

▶ Two films from Lockheed Aircraft Corporation, *Here Comes Hercules* and *Hydrostatic Testing of the C-130A*, were shown at the March 12 meeting. They depicted early construction and extensive ground and flight testing of the prototype and the aircraft's performance.

ALLEN J. SCHNEIDER
Recording Secretary

Rensselaer Polytechnic Institute

New officers elected at the April 10 meeting were Chairman, Arthur Sutherland; Vice-Chairman, David Ward; and Secretary-Treasurer, Charles Kromer.

After elections the following films were shown: *The Snark*, produced by Northrop Aircraft, Inc.; *Guiding a Helicopter*, by Hiller Helicopter Co.; *High Speed Flight Research*, by NACA; and *The AJ-1* and *F-86 Sabre-Jet*, by North American Aviation, Inc.

ROBERT E. KELLY
Secretary-Treasurer

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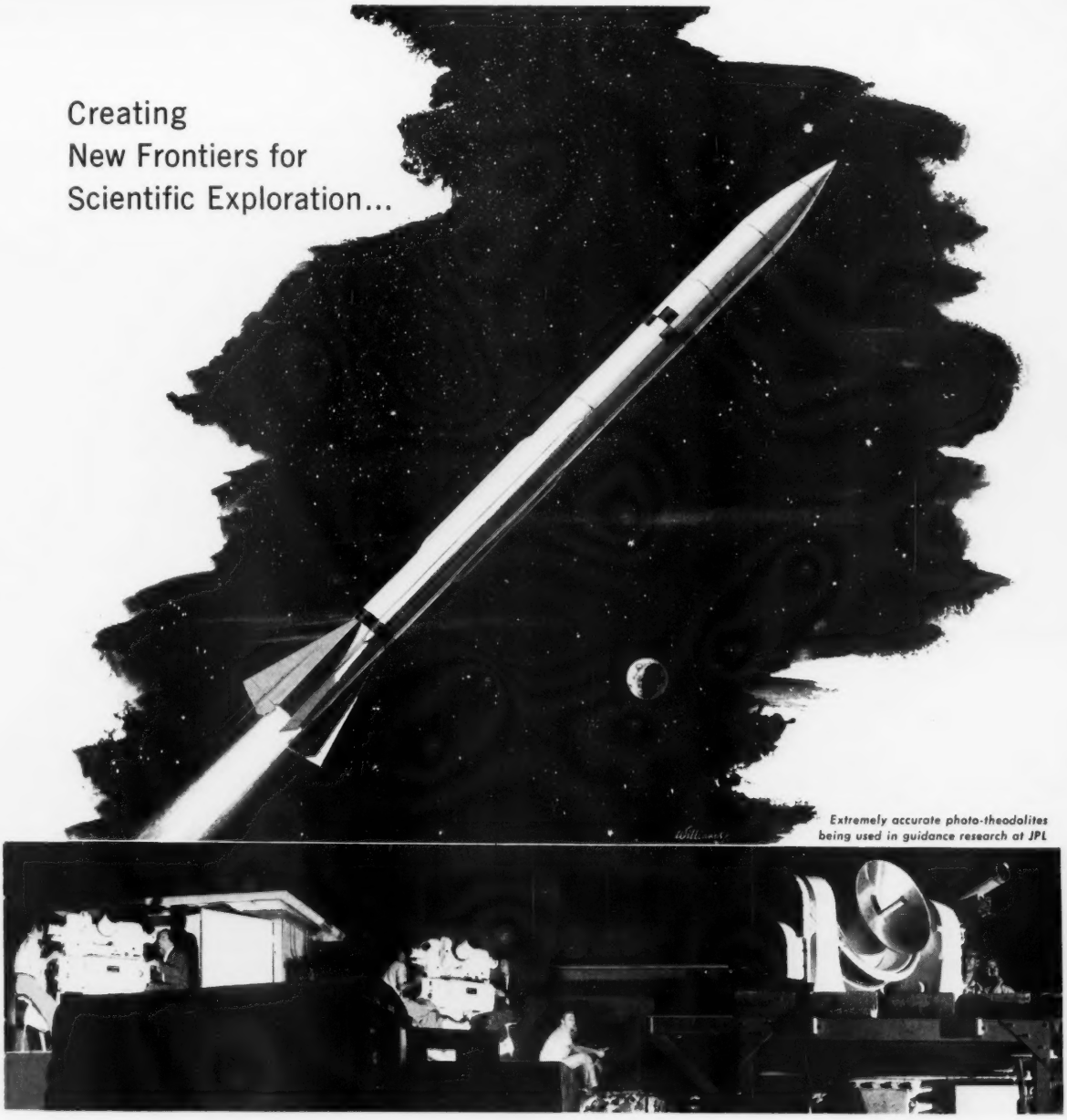

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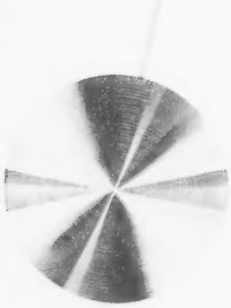

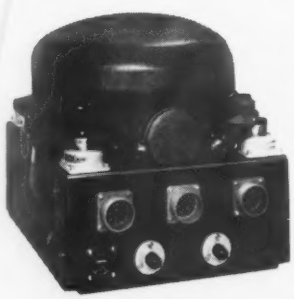

INERTIAL SYSTEM PLATFORM

This three gyro inertial platform is representative of the units now in production at Kearfott. It incorporates accelerometers, floated rate integrating gyros, data transmitting components and basic structural designs which exemplify the current state of the art.

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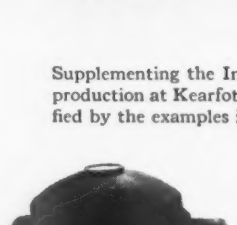

CENTRAL GYRO REFERENCE SYSTEM

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ALL-ATTITUDE COMPASS SYSTEM

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San Diego State College

Dennis O'Leary spoke on "Bay Pollution" at a joint meeting of the Branch and its SAE and ASCE counterparts on April 9. Mr. O'Leary is on the California State Water Pollution Control Board.

JAMES R. FRAHM, *Secretary*

Stevens Institute of Technology

Members saw two films, *The Kaman Turbine Helicopter* and *X Minus Zero*, at the April 10 meeting.

Advantages of turbine over conventionally powered helicopters were displayed in the first film. Turbine craft use a lower grade fuel, are lighter, require less maintenance, and have a lower noise level.

The second film showed a test flight of the Matador surface-to-air missile. Much attention was placed upon checks and safeguards prior to firing. In addition to standard check-out, Air Force personnel keep the testing area free of human occupancy with search planes and boats.

JAMES E. ROE
Corresponding Secretary

Tri-State College

A film, *The Story of the Flying Wing*, produced by Northrop Aircraft, Inc., was shown at the May 2 meeting. Features of the Flying Wing were shown to be reduction of drag by elimination of the fuselage, greater pay load, and increase in range.

▶ Arrangements for a field trip to Wright Field, Dayton, Ohio, were completed at the April 17 meeting. The schedule called for visiting Dayton on May 19 and the North American Aviation, Inc., facilities at Columbus, Ohio, on May 20.

A committee was formed to prepare the Branch's contribution to the 1957 alumni homecoming display, the theme of which is "Contributions of Engineering and Commerce to Society." Engineering societies will compete for awards in the event.

▶ A report on the Institute's Annual Meeting in January was presented to 69 members by Quintin J. Hawthorne, Head of the Aeronautical Engineering Department, on April 4.

Professor Hawthorne said IAS members may obtain valuable information from the lectures presented which cover different aspects of the aeronautical field. There also is opportunity to meet leading men in the field.

Two films, *Princeton Smoke Flow Visualization Program* and *Jet Age*, were shown. The first depicted experiments on airfoil sections in a smoke tunnel; the second showed Canada's contributions to the jet age.

KAZUMI HAMADA, *Secretary*

University of Kentucky

Andy Byrnes, Aerodynamicist, Fighter Projects, North American Aviation, Inc., Columbus Division, spoke on "Problems Associated With the Development of High-Speed Fighter Aircraft" at the April 25 meeting. Mr. Byrnes supplemented his talk with a movie showing sled tests of the FJ-4 Fury. A discussion followed the movie and Mr. Byrnes's talk.

A. L. WITTWER, *Secretary*

University of Texas

Faculty Adviser William H. Shutts presented awards to two outstanding aeronautical students at the April 15 meeting.

A scholastic award was presented to Emory K. Damstrom who has maintained the highest grade average in the department. A lecture award was given to Dave Moore for his paper which won the Branch Student Paper Competition.

A movie on rocket sled flutter testing was shown.

▶ Plans for participation in the Power Show and Exposition were made at the March 18 meeting.

Some 50 members decided on "Class Work in Aeronautical Engineering" for the theme for the Power Show. This will be developed by some laboratory demonstrations of theory studied in classes. Displays showing structural and aerodynamic theory will be set up.

A film, *Eyes of the Range*, dealing with optical and electrical missile tracking devices at White Sands Proving Ground was shown.

Graduate student Carson Lyons and undergraduate Dave Moore were named winners of the Branch Student Paper Competition held February 25. Mr. Lyons' paper, "Design of an Acceleration Insensitive Skin Friction Balance," also placed first in the Fort Worth regional competition (graduate division) in April.

Mr. Moore won third place at Fort Worth for his paper on "An Analytical Investigation of a Local Mach Number of One Extending Into the Laminar Sublayer of a Turbulent Boundary Layer."

Judges for the Branch competition were M. J. Thompson and J. W. Dalley, of the Aeronautical Engineering faculty, and J. L. Harkness and F. W. Fenter, Defense Research Laboratory.

ROBERT W. COURTER
Corresponding Secretary

U.S. Air Force Institute of Technology

About 85 members and guests saw two films, *ARDC Staff Film Reports* (27 and 29), at the April 12 meeting. Both films were classified. These films are monthly progress reports on various ARDC projects.

The meeting was cosponsored by the Pi Epsilon Gamma Honor Society.

After the film showing, plans for recruiting new members from recently enrolled classes were discussed.

1ST LT. ALIDORE A. JANCAUSKAS, USAF
Secretary

U.S. Naval Postgraduate School

A discussion of "Systems Analysis of Fleet Airborne Early Warning" was presented on April 24 by D. L. James, Department Manager for Navy Studies, and George Arnold, Project Engineer, Airborne Early Warning, Lockheed Aircraft Corporation.

Mr. James, who opened the discussion, covered the general scope of the Lockheed

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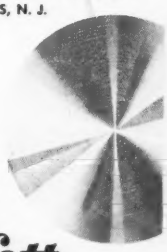

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study. Mr. Arnold gave a more detailed account of assumptions made, methods used, and general results. He also sketched plans for further development.

Some 20 members and guests attended the lecture which was classified Secret.

GEORGE E. JESSEN
Corresponding Secretary

MEMBERS ELECTED

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the Review.

Elected to Associate Fellow Grade

Ramo, Simon, Ph.D. in E.E. & Physics, Exec. V-P, The Ramo-Wooldridge Corp.

Rugge, Raymond A., B.S. in E.E., V-P, R&D, The W. L. Maxson Corp.

Weed, Donald W., Chief Systems Designer, Republic Aviation Corp. (Farmingdale).

Wooldridge, Dean E., Ph.D. in Physics, Pres., The Ramo-Wooldridge Corp.

Transferred to Associate Fellow Grade

Ellis, Macon C., Jr., B.S. in Ae.E., Head, Gas Dynamics Branch, NACA (Langley Field).

Fallis, William B., Ph.D. in Ae.E., Group Engr., Theoretical Aerodynamics, Convair Div. (Ft. Worth), General Dynamics Corp.

Finnimore, John R., Design Supt., BOAC (London Airport).

Goland, Leonard, M.S. in Ae.E., Dir., Research, Kellett Aircraft Corp.

Hoover, John W., M.S. in Ae.E., Interim Head Prof., Aero. Engrg., Univ. of Florida.

Kroon, Reinout P., Dipl. Eng., Dir. of Research, AGT Div., Westinghouse Electric Corp. (Kansas City).

Lin, Chia-Chiao, Ph.D. in Aero., Prof. of Math., Massachusetts Institute of Technology.

Meckley, William O., B.S. in M.E., Mgr., Commercial Engines and Accessories, European Tech. Service, General Electric Co. (Geneva).

Ross, Franklin J., M.S. in Ae.E., Tech. Dir., Flight Test, USAF, AF Flight Test Center (Edwards AFB).

Seredinsky, Vladimir, Dipl. Eng., Group Engr., Aerodynamics, Stroukoff Aircraft Corp.

Wassall, John B., Dir., Engrg., Lockheed Aircraft Corp. (Burbank).

Williams, Walter C., B.S. in Ae.E., Chief, NACA High Speed Flight Test Station (Edwards AFB).

Elected to MEMBER Grade

Baljé, O. E., Dr.Eng., Engrg. Consultant (self-employed).

Beach, Laurence R., M.S. in M.E., Engr., Stromberg-Carlson Co. Div., General Dynamics Corp.

Beremand, Donald G., B.S. in M.E., Proj. Engr., Thompson Products, Inc.

Berkey, Donald C., M.S. in M.E., Mgr., Appl. Research, General Electric Co. (Cincinnati).

Berlad, Abraham L., Ph.D. in Physics, Sr. Staff Scientist, Scientific Research Lab., Convair Div. (San Diego), General Dynamics Corp.

Bernstein, Harry, M.S. in Ae.E., Aerodynamics Engr., Radioplane Co.

Bertaux, Walter S., B.S. in M.E., Mgr., Exhaust Systems Engrg., AGTD, General Electric Co. (Evendale).

Bishop, Donald J., M.S. in Math., Sr. Group Engr., Boeing Airplane Co.

Bleich, Lewis A., M.S., Sr. Devel. Engr., Aero. Div., Minneapolis-Honeywell Regulator Co.

Bonney, James O., B.S. in M.E., Group Engr., Radioplane Co.

Bray, Richard J. G., Chief Draftsman, British Aviation Services (Engrg.), Ltd.

Brown, Charles R., M.S. in M.E., Proj. Engr., Westinghouse Electric Corp. (Kansas City).

Brunk, Sherman V., Sr. Design Engr., Convair Div. (Ft. Worth), General Dynamics Corp.

Buckingham, Arthur G., B.S. in E.E., Engr., Air Arm Div., Westinghouse Electric Corp. (Baltimore).

Burns, William E., B.S. in M.E., Proj. Engr., Propeller Div., Curtiss-Wright Corp. (Caldwell).

Chiswell, Earl, B.S. in E.E., Staff Engr., The Martin Co.

Cochrane, John A., B.S. in M.E., Sr. Propulsion Engr., The Martin Co. (Baltimore).

Cowdrey, M. V., Sales Engr., Marquardt Aircraft Co.

Crowley, John V., B.E., Research Engr. "A," Radioplane Co.

Czarnecki, Edwin G., B.S. in Ae.E., Head, Special Assignments, Struct. Staff, Boeing Airplane Co.

Decher, Siegfried H., Staff Engr., Lycoming Div., Avco Manufacturing Corp.

De Furia, Anthony, B.S. in M.E., Assoc. Scientist, Avco Manufacturing Corp.

Denlinger, Herbert H., Mgr., Research Facilities, Proj. Devel. Div., The Ralph M. Parsons Co.

Doman, James P., B.S. in Ae.E., Supvr., High Temperature & Experimental Struct. Branch, Naval Air Material Center (Philadelphia).

Doolittle, Donald B., B.S. in Ae.E., V-P, Engrg. and Production, All American Engineering Co.

Driskill, Leonidas P., B.S. in M.E., Flight Test Engr. "A," Missile Systems Div., Lockheed Aircraft Corp. (Van Nuys).

Epperson, Thomas B., M.S. in Appl. Mech., Mgr., Aeroelasticity, Southwest Research Institute.

Eustis, Robert H., Sc.D., Assoc. Prof., Stanford Univ.

Fornoff, Heinz, B.S. in M.E., V-P & Chief Engr., Specialties, Inc.

Forthoffer, Franklin O., M. of Ae.E., Major, USAF; R&D Aero. Engr. & Planner.

Gabriel, Albert W., Jr., B.S., Sr. Designer, Vertol Aircraft Corp.

George, Merton B. T., Ph.D. in Ae.E., Research Scientist, Avco Research Lab., Avco Manufacturing Corp. (Everett).

Gibson, Robert G., M.S., Asst. Weapon System Mgr., Missiles Systems Div., Lockheed Aircraft Corp. (Van Nuys).

Giragosian, Pakrad A., B.S. in Ae.E., Aerodynamicist, General Electric Co. (Philadelphia).

Greengard, Russell L., B.S., Aerodynamic Engr., Propulsion Research Corp.

Gretzinger, John R., B.S. in M.E., Chief Engr., Fuel Systems & Components, Allison Div., General Motors Corp. (Indianapolis).

Hall, John G., Ph.D. in Ae.E., Research Assoc. and Asst. Prof., Institute of Aerophysics, Univ. of Toronto.

Heller, Robert A., M.S. in C.E., Instructor, Columbia Univ.

Hoover, Leroy R., B.S. in Physics, Contract Engr., Harper Consultants & Contract Engineers.

Hughes, Cyril G., D.C. in Ae.E., Sr. Aerodynamicist, Short Brothers and Harland Ltd. (Belfast).

Kindle, Howard C., Group Design Engr., Thieblot Aircraft Co.

Lattey, J. I., M.A., Sect. Leader, Vickers-Armstrongs (Aircraft), Ltd.

Long, Palmer L., B. of Ae.E., Asst. Test Proj. Engr., Douglas Aircraft Co., Inc. (Santa Monica).

Luber, Joseph L., B.S. in M.E., Design Engr., Appl. Physics Lab., The Johns Hopkins Univ.

Luidens, Roger W., B.S. in Ae.E., Aero. Research Scientist, NACA (Cleveland).

Mawhinney, Robert F., Jr., B.S. in Ae.E., Sr. Aerodynamic Engr., Convair Div. (San Diego), General Dynamics Corp.

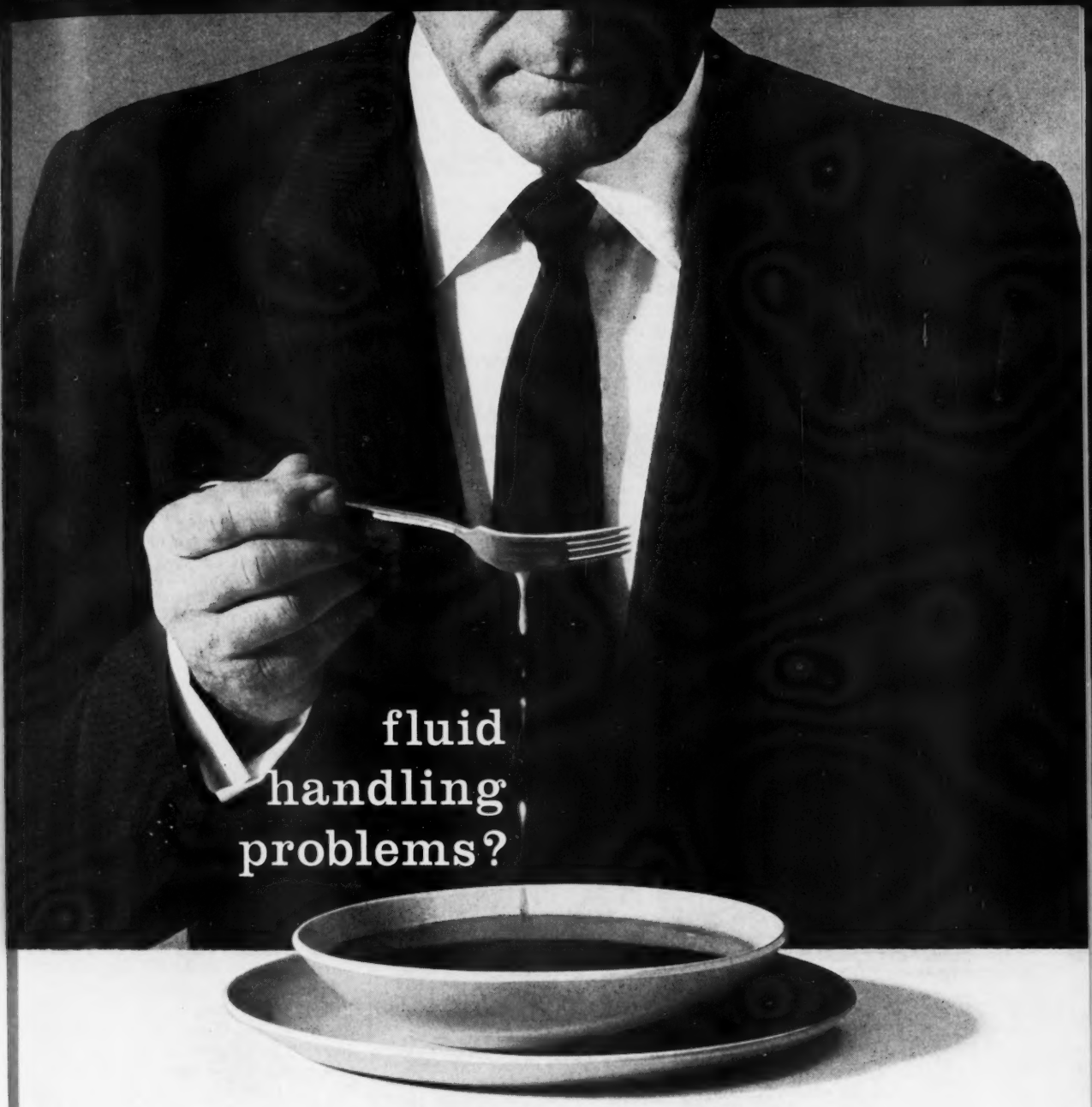
McCracken, Donald W., B.S. in C.E., Experimental Test Pilot, McDonnell Aircraft Corp.

Methlie, Edwin W., B.S. in M.E., Engr., Northrop Aircraft, Inc.

Millar, Doulgas A. J., Sc.D. in M.E., Analytical Engr., Canadian Pratt & Whitney Co., Ltd.

Miller, Douglas S., B.S. in Ae.E., Aerodynamicist, Boeing Airplane Co.

Mills, Spencer, Sect. Leader, Forward Design Planning, Blackburn & General Aircraft, Ltd.



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Moe, Herbert C., M.S. in M.E., Thermodynamics Engr., Lockheed Aircraft Corp. (Burbank).

Moores, Richard C., B.S. in Ae.E., Chief, Eastern Field Engrg., United Aircraft Corp.

Morrin, Laurence, B.S. in Ae.E., Test Proj. Engr., Douglas Aircraft Co., Inc. (Santa Monica).

Odlum, Edward J., M.S. in E.E., Sr. V-P, Kaman Aircraft Corp.

Owen, John R., B. of Ae.E., Staff Engr., Ramo-Wooldridge Corp. (Patrick AFB).

Philliou, Peter J., B.S. in M.E., Engr., Gruen Applied Science Lab.

Pitcher, Harlan E., B.S. in C.E., Chief, Mech. Design Sect., Douglas Aircraft Co., Inc. (El Segundo).

Povolny, John N., M.E., Head, Propulsion Systems Lab., NACA (Cleveland).

Ranck, William A., Jr., B. of M.E., Research Engr., Missile Systems Div., Lockheed Aircraft Corp. (Van Nuys).

Reeves, Walter R., Jr., M.S. in Engrg. Mech., Group Engr., Convair Div. (Ft. Worth), General Dynamics Corp.

Reid, Frank A., III, M.S. in Ae.E., Sr. Engr., Aeroballistics Group, Chrysler Missile Operations.

Rousso, Morris D., B.S. in M.E., Sr. Research Engr., Engrg. Research Lab., Lockheed Aircraft Corp. (Marietta).

Seid, Albert J., M.S. in M.E., Supvr., Mech. Design, Turbomotor Div., Curtiss-Wright Corp.

Sheffield, Warren B., B.S. in E.E., Engrg. Dept. Head, Sperry Gyroscope Co. Div., Sperry Rand Corp.

Shepard, Charles E., B.S., Proj. Engr., Lewis Flight Propulsion Lab., NACA (Cleveland).

Shoop, Clarence A., V-P, Hughes Aircraft Co.

Snoke, Donald R., B.S. in M.E., Research Engr., Thompson Products, Inc.

Stek, J. B., M. of M.E., Proj. Engr., Curtiss-Wright Corp.

Stringas, Emanuel J., Research Engr., Research Div., Curtiss-Wright Corp.

Summers, Lowell P., M.S., Asst. Prof., Aero., Utah State Univ.

Sutherland, Rodney D., M.S., Sr. Thermodynamics Engr., Convair Div. (Pomona), General Dynamics Corp.

Sutor, Alois T., M.S. in M.E., Engrg. Research Specialist, Rocketdyne Div., North American Aviation, Inc. (Canoga Park).

Tereshkow, Henry, B.S. in M.E., Chief Proj. Engr., Avco Manufacturing Corp.

van Summern, John S., B.S. in Ae.E., Missile Synthesis Engr., General Electric Co. (Philadelphia).

Velie, Wallace W., B.S. in Ae.E., Engrg. Specialist, Marquardt Aircraft Co. (Van Nuys).

Vinson, Jack R., B.S. in M.E., Proj. Engr., Prelim. Design, Aerosciences Lab., General Electric Co. (Philadelphia).

Wales, Peter A., Design Group Leader, BOAC (London Airport).

Wallis, Thomas M., B.S. in E.E., Mgr., Aircraft Instruments Prod. Engrg., General Electric Co. (Lynn).

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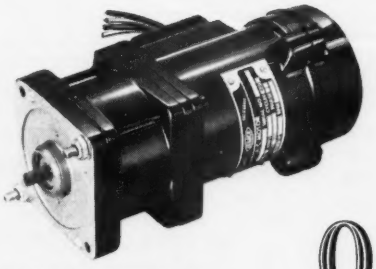

Type: C-1874 400 cycle 3 phase AC Motor and Clutch. **Weight:** 4.5 lbs. **Voltage:** 200 volts. **Output:** 650 watts. **Intermittent duty:** 12,000 rpm. **Meets Military Specification** MIL-M-7969A (ASG).

Type: D-638 400 cycle AC Motor. **Weight:** 17.5 lbs. **Voltage:** 200 AC, 20 amps at 6.5 hp. **Duty cycle:** 3.0 seconds at 6.5 hp, 15.0 seconds at 1.5 hp. **Maximum capacity:** 6.5 hp. **Continuous rating:** 5 hp at 2300 rpm, 15.8 amps, 200 volts. **Meets Military Spec.** MIL-M-7969A (ASG).

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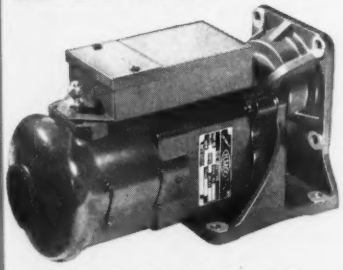
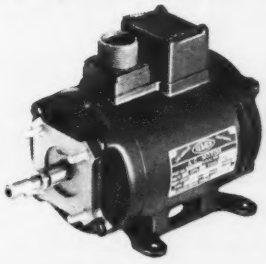
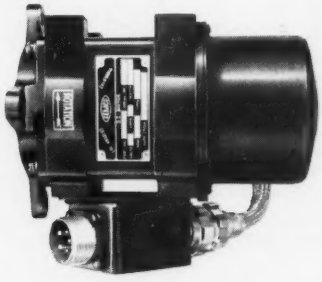


Type: D-751 DC Motor. **Weight:** 20 lbs. **Duty Cycle:** 5.2 hp at 2100 rpm (intermittent) on 26 volts DC; 3.5 hp at 2200 rpm (continuous) on 26 volts DC. **Meets Military Specification** MIL-M-8609.

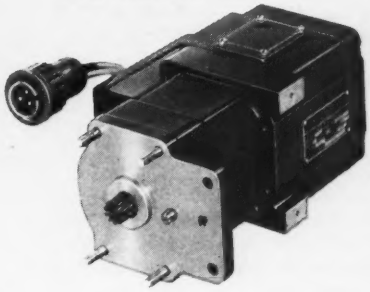


Type: D-800 400 cycle 3 phase AC Motor. **Weight:** 8.75 lbs. **Voltage:** 208 volts. **Horsepower:** 2.5 hp. **Continuous Duty:** 11,300 rpm; Equipped with thermal protector. **Meets Military Specification** MIL-M-7969A (ASG).

Type: D-899 400 cycle 3 phase AC Motor. **Weight:** 11.25 lbs. **Volts:** 200 volts. **Load:** 2.75 hp continuous output. **RPM:** 3140 rpm output at gear box. **Power factor:** 83%. **Overall efficiency:** 76% for entire unit. **Meets Military Specification** MIL-M-7969A (ASG).



Type: D-932 DC Motor. **Weight:** With radio noise filter—13 lbs., without same—12.4 lbs. **Terminal voltage:** 27.5 DC plus or minus 1.5 volts. **Load:** From .5 hp minimum to 2.6 hp maximum. **Speed:** Continuous at 12,000 rpm, plus or minus .005%. **Speed Control:** By frequency regulator supplying control field. **Meets Military Specification** MIL-M-8609 (ASG).



Type: D-927 DC Motor. **Weight:** 7.25 lbs. with 2-circuit noise filter for ungrounded systems. **Weight of filter:** 1 lb. **Terminal voltage:** 27 volts, 18 amps. **Load:** 0.5 hp. **Speed:** Continuous at 9900 rpm. **Meets Military Specification** MIL-8609.

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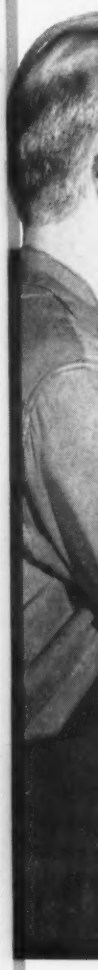

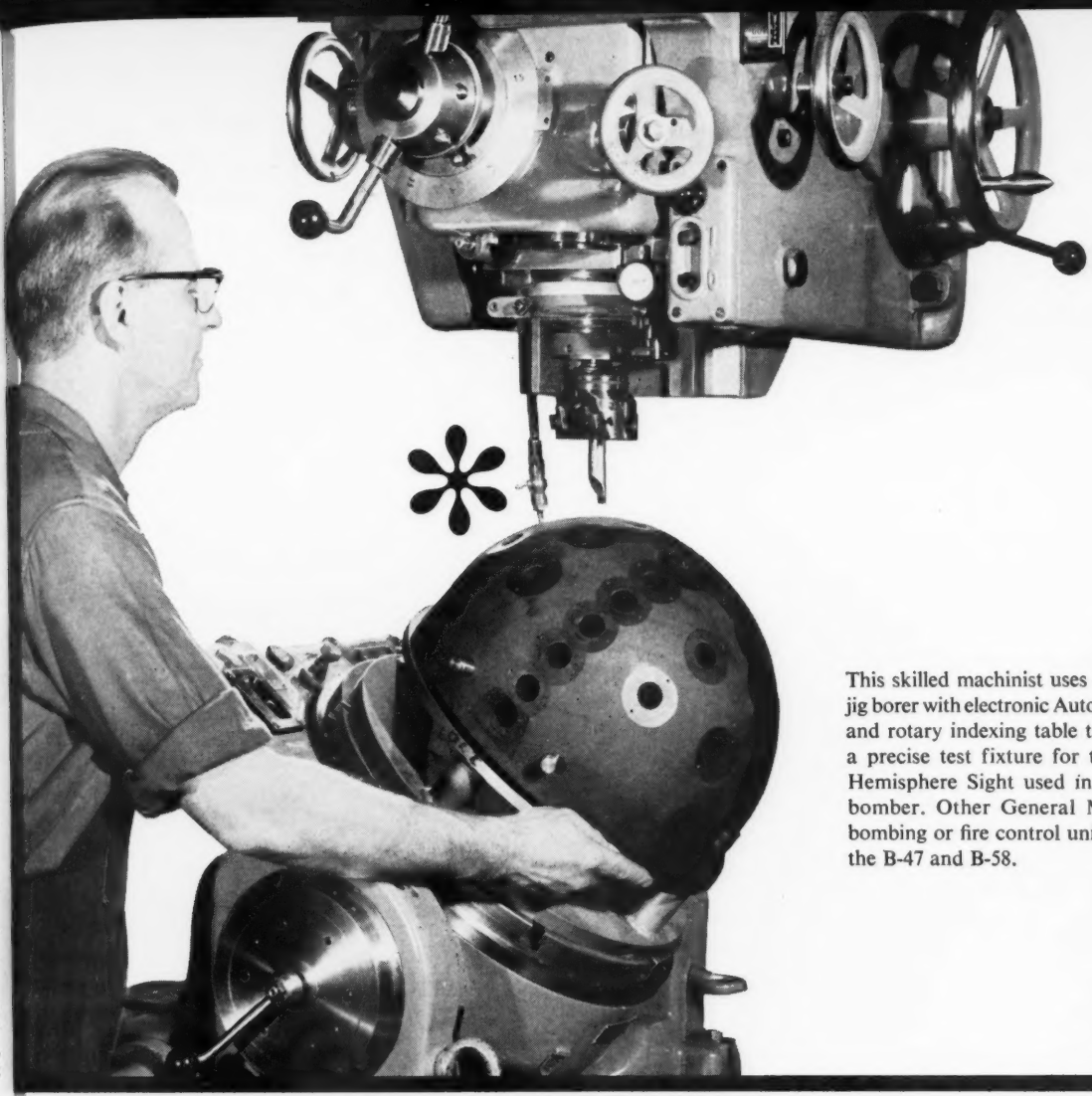

This skilled machinist uses a Lindner jig borer with electronic Autopositioner and rotary indexing table to produce a precise test fixture for the MD-9 Hemisphere Sight used in the B-52 bomber. Other General Mills-built bombing or fire control units fly with the B-47 and B-58.

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Maintaining accuracy of the MD-9 Hemisphere Sight for the tail defense system in B-52 bombers calls for unusually close tolerances. Holding these tolerances requires exacting test fixtures. We designed, engineered and built many of them.

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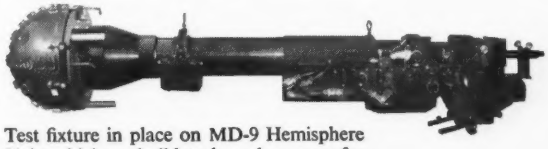
We'd like to tell you more about how we combine creative engineering and fine precision production to serve industry and military. Our unified team can handle research, development or manufacturing—or the whole package. Send for facts, Dept. AR7



Test fixture in place on MD-9 Hemisphere Sight which we build under subcontract for the Crosley Division of Avco.

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These periodicals are maintained in the IAS Library and are made available through its lending, photocopy, and reference facilities. The IAS Library does not sell these publications.

Acad. Pol. Sci. Bul. Académie Polonaise des Sciences, Bulletin, Sniadeckich 8, Warsaw 10, Poland, Irreg.

Acta Polytechnica. Royal Swedish Academy of Engineering Sciences, Stockholm, Sweden, Irreg.

Aerial. Marconi's Wireless Telegraph, Chelmsford, Essex, Eng., Q

Aero, Herman Lingg Strasse 9, Munich 15, Germany, M, DM 12

Aero Dig. Aero Digest, 14th & F Streets, NW, Washington 4, D.C., M, $5

Aero. Eng. Rev. Aeronautical Engineering Review. Institute of the Aeronautical Sciences, Inc., 2 E. 64 St., New York 21, N.Y., M, $3

Aéro France. Aéro Club de France, 6, rue Galilée, Paris 16, France, M, 1,200 fr.

Aero Mag. Aero Magazine (Supplement to Velocidade), Caixa Postal 4917, São Paulo, Brazil, M, Cr$200 (2 years)

Aero. Purchasing. Aeronautical Purchasing, 812 Huron Road, Cleveland 15, Ohio, M, $6

Aero. Quart. Aeronautical Quarterly. Royal Aeronautical Society, 4 Hamilton Place, London W 1, England, Q, $8.55

Aero Res. TN. Aero Research Technical Notes. Aero Research Ltd., Duxford, Cambridge, England, M

Aero. Soc. of India J. Aeronautical Society of India, Journal, New Delhi, India, Q, $2

Aeronautics, Tower House, Southampton St., Strand, London WC 2, England, M, 33s.

Aéronaves, Edificio Zingg, Caracas, Venezuela. BM

The Aeroplane, Bowling Green Lane, London EC 1, England, W, $14

Aeroporika Nea, 4 Othonos St., Athens, Greece, M

L'Aerotecnica. Associazione Italiana di Aerotecnica, Piazza S. Bernardo 101, Rome, Italy, M, L.3,000

Aerovox Res. Worker. Aerovox Research Worker. Aerovox Corp., New Bedford, Mass., M

Les Ailes, 77, blvd. Malesherbes, Paris 8, France, W, 1,200 fr.

L'Air, 71 Champs-Elysées, Paris 8, France, M, 1,500 fr.

Air Age, Mehta House, Apollo St., Bombay 1, India, BM, 12 rupees

Air BP. The British Petroleum Co., Ltd., Finsbury Circus, London, EC 2, England, Q

Air Facts, 30 Rockefeller Plaza, New York 20, N.Y., M, $3

Air Force. Air Force Assn., Mills Bldg., Washington 6, D.C., M, $4

Air Line Pilot, Air Line Pilots Assn., International, 55 St. & Cicero Ave., Chicago 38, Ill., M, $2.50

Air Pictorial. Air Pictorial and Air Reserve Gazette. Air League of the British Empire, Londonderry House, 19 Park Lane, London W 1, England, M, £1

Air Rev. Air Revue, 11 rue de Crayer, Brussels, Belgium, M, 350 fr. belge

Air Safety Dig. Air Safety Digest. Flight Safety Foundation, 468 4th Ave., New York 16, N.Y., Q

Air Transp. Air Transportation, 10 Bridge St., New York 4, N.Y., M, $5

Air U. Quart. Rev. Air University Quarterly Review, Maxwell AFB, Ala., Q, $2

Aircraft (Australia). Royal Aeronautical Society, Australian Division, etc., 26 Flinders St., Melbourne, Australia, M, 30s.

Aircraft (Canada), 341 Church St., Toronto 2, M, $5

Aircraft Eng. Aircraft Engineering, 12 Bloomsbury Sq., London WC 1, England, M, 35s.

Aircraft Heating Dig. Aircraft Heating Digest. Janitrol Aircraft-Automotive Division, Surface Combustion Corp., Columbus 16, Ohio, Irreg.

Aircraft Prod. Aircraft Production, Dorset House, Stamford St., London SE 1, England, M, $6

Airplane Patent Dig. Airplane Patent Digest. Manufacturers Aircraft Assn., Inc., 45 Rockefeller Plaza, New York 20, N.Y., SM

Airports & Air Transp. Airports and Air Transportation, 92 Victoria St., London SW 1, England, BM, 15s.

Allis-Chalmers Elec. Rev. Allis-Chalmers Electrical Review. Allis-Chalmers Mfg. Co., Milwaukee, Wis., Q, $2

AHS J. American Helicopter Society, Journal, 2 E. 64 St., New York 21, N.Y., Q, $4

AHS Newsletter. American Helicopter Society, Newsletter, 2 E. 64 St., New York, 21 N.Y., M, $3

Am. Av. American Aviation, 1001 Vermont Ave., NW, Washington 5, D.C., SM, $5

Am. Engr. American Engineer. National Society of Professional Engineers, 2029 K St., NW, Washington 6, D.C., M, $3

Am. Helicopter. American Helicopter, 32 E. 57 St., New York 22, N.Y., M, $3.50

American Aviation Daily, 1001 Vermont Ave., NW, Washington 5, D.C., Daily, $200

AMS Bul. American Meteorological Society, Bulletin, 3 Joy St., Boston 8, Mass., 10 issues per year, $8

AN SSSR Dokl. Akademiia Nauk SSSR, Doklady, Moscow, U.S.S.R., 36 issues per year

AN SSSR Mat. Inst. Trudy. Akademiia Nauk SSSR, Matematicheskii Institut, Trudy, Moscow, U.S.S.R., Irreg.

AN SSSR Otd. Tekh. Nauk Izv. Akademiia Nauk SSSR, Otdelenie Tekhnicheskikh Nauk, Izvestiia, Moscow, U.S.S.R., M

Anal. Chem. Analytical Chemistry. American Chemical Society, 1155 16th St. NW, Washington 6, D.C., M, $4.50

Annals Phys. Annals of Physics, 111 5th Ave., New York 3, N.Y., M, $22

Appl. Hydraulics. Applied Hydraulics, 1240 Ontario St., Cleveland 13, Ohio, M, $5

Appl. Mech. Rev. Applied Mechanics Reviews. Southwest Research Institute, 8500 Culebra Rd., San Antonio 6, Tex., M, $25

Appl. Sci. Res., Sect. A. Applied Scientific Research, Section A, 9 Lange Voorhout, The Hague, Netherlands, Irreg., 21.50 guilder

Appl. Sci. Res., Sect. B. Applied Scientific Research, Section B, 9 Lange Voorhout, The Hague, Netherlands, Irreg., 21.50 guilder

Approach. U.S. Naval Aviation Safety Center. Supt. of Documents, Washington 25, D.C., M, $2.50

Arch. Budowy Maszyn. Archiwum Budowy Maszyn. Polska Akademia Nauk, ul. Nowy Swiat 72, Warsaw, Poland, Q, 80 zl.

Arch. Mech. Stosowanej. Archiwum Mechaniki Stosowanej. Polska Akademia Nauk, ul. Nowy Swiat 72, Warsaw, Poland, Q, 100 zl.

Argentina Aérea, Moreno 360, Buenos Aires, Argentina, M, $3

ASEA Journal. ASEA, Västerås, Sweden, M

ASME Trans. American Society of Mechanical Engineers, Transactions, 29 W. 39 St., New York 18, N.Y., 8 issues per year, $12

Asoc. Argent. Interplan. Rev. Asociación Argentina Interplanetaria, Revista, Viamonte 867, Buenos Aires, Argentina, Q

Assoc. Comp. Mach. J. Association for Computing Machinery, Journal, 2 E. 63rd St., New York 21, N.Y., Q, $10

ASTM Bul. American Society for Testing Materials, Bulletin, 1916 Race St., Phila. 3, Pa., 8 issues per year, $2.75

Astronautica Acta, Molkerbastei 5, Vienna 1, Austria: I. R. Maxwell & Co., Ltd., London, Paris, New York, Q, $8.60

Auster News. Auster Aircraft Ltd., Rearsby Aerodrome, Leicester, Eng., Q

Australian J. Appl. Sci. Australian Journal of Applied Science. Commonwealth Scientific & Industrial Research Organization, 314 Albert St., East Melbourne C.2, Victoria, Australia, Q, £2

Australian J. Phys. Australian Journal of Physics. Commonwealth Scientific and Industrial Research Organization, 314 Albert St., East Melbourne C.2., Australia, Q, 30s.

Auto. Control. Automatic Control, 430 Park Ave., New York 22, N.Y., M, $10

Auto. Ind. Automotive Industries, Chestnut & 56 Sts., Phila. 39, Pa., SM, $2

Av. Age. Aviation Age, 205 E. 42 St., New York 17, N.Y., M, $10

Av. Res. & Devel. Aviation Research & Development, 140 E. 40th St., New York 16, N.Y., M, $10

Av. Week. Aviation Week, 330 W. 42 St., New York 36, N.Y., W, $6

Avia Vliegwereld. Royal Aero Club of the Netherlands, Anna Paulownaplein 3, The Hague, Netherlands, BW, 11 fl.

Aviação, Rua Uruguaiana 104-4, Rio de Janeiro, Brazil, M, Cr$600

Aviation Week Market Letter, 330 W. 42 St., New York 36, N.Y., M

Avión. Reál Aéro Club de España, Carrera de San Jerónimo 19, Madrid, Spain, M, 250 pesetas

Avtom. i Telemekh. Avtomatika i Telemekhanika. Institut Avtomatiki i Teemekhaniki, Otdelenie Tekhnicheskikh Nauk, Akademiia Nauk SSSR, Moscow, U.S.S.R., M

Battelle Tech. Rev. Battelle Technical Review. Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio, M

Bearing Engr. Bearing Engineer. The Torrington Company, 444 Madison Ave., New York 22, N.Y., Irreg.

Bee Hive, United Aircraft Corp., East Hartford, Conn., Q

Bell System Tech. J. Bell System Technical Journal. American Telephone and Telegraph Co., 195 Broadway, New York 7, N.Y., BM, $3

BOAC Review. British Overseas Airways Corp., Stratton House, Piccadilly, London W 1, England, M

Boeing Mag. Boeing Magazine. Boeing Airplane Co., 7755 E. Marginal Way, Seattle, Wash., M

Bristol Quart. The Bristol Quarterly. Bristol Aeroplane Company, Ltd., Filton House, Bristol, England, Q

Brit. Aircraft Ind. Bul. British Aircraft Industry Bulletin. Society of British Aircraft Constructors, 29 King St., St. James, London SW 1, England, Q

Brit. Interpl. Soc. J. British Interplanetary Society, Journal, 12 Bessborough Gardens, London SW 1, England, BM, 24s.

Brit. J. Appl. Phys. British Journal of Applied Physics. Institute of Physics, 47 Belgrave Sq., London SW 1, England, M, $11.50

Brit. Welding J. British Welding Journal. Institute of Welding, 2 Buckingham Gardens, London, SW 1, England, M, £5

Brown Boveri Rev. Brown Boveri Review. Brown, Boveri & Co., Ltd., Baden, Switzerland, M

Bul. Liais. Doc. Bulletin de Liaison et de Documentation du Secrétariat Général à l'Aviation Civile et Commerciale, 93 blvd. du Montparnasse, Paris 6, France, BM

Bul. Stiint. Sect. Stiinte Mat. Fiz. Bulletin Stiintific, Sectiunea de Stiinte Matematice si Fizice, Academia Republicii Populare Romine, Bucarest, Rumania, Q

BWK. Brennstoff-Wärme-Kraft. VDI-Verlag, Bongardstrasse 3, Düsseldorf, Germany, M, DM 52

Cambridge Philos. Soc. Proc. Cambridge Philosophical Society, Proceedings, Free School Lane, Cambridge, England, Q, £5

Can. Aero. J. Canadian Aeronautical Journal. Canadian Aeronautical Institute, Commonwealth Building, 77 Metcalfe St., Ottawa, Canada, M, $4

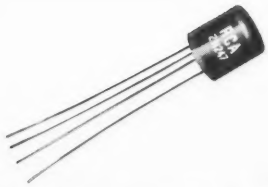
Can. Airline Pilot. The Canadian Airline Pilot. The Canadian Airline Pilots Assn., 400 Electric Railway Chambers, Winnipeg, Manitoba, Canada, Q

Can. Flight. Canadian Flight, Canadian Owners & Pilots Assn., Box 734, Sta. B, Ottawa, Ont., Canada, BM, $4

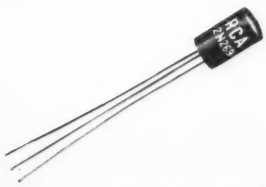
Can. J. Phys. Canadian Journal of Physics. National Research Council, Ottawa 2, Canada, M, $4

Can. J. Tech. Canadian Journal of Technology. National Research Council, Ottawa 2, Canada, BM, $3

Canada, NAE Quart. Bul. Canada, National Aeronautical Establishment, Quarterly Bulletin, Montreal Road, Ottawa, Canada, Q



RCA-2N247—"Drift" Transistor for use as an RF amplifier in the AM broadcast-band and up into the short-wave bands. Flexible leads.



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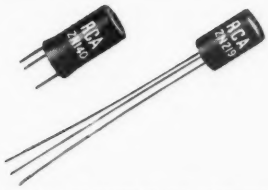

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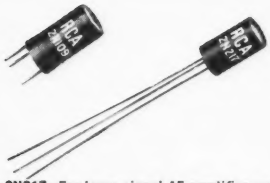

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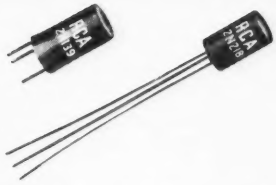

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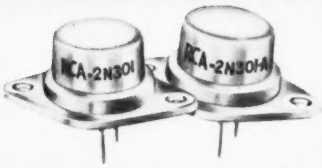

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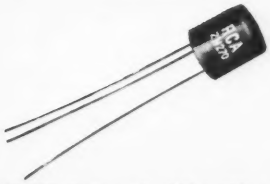

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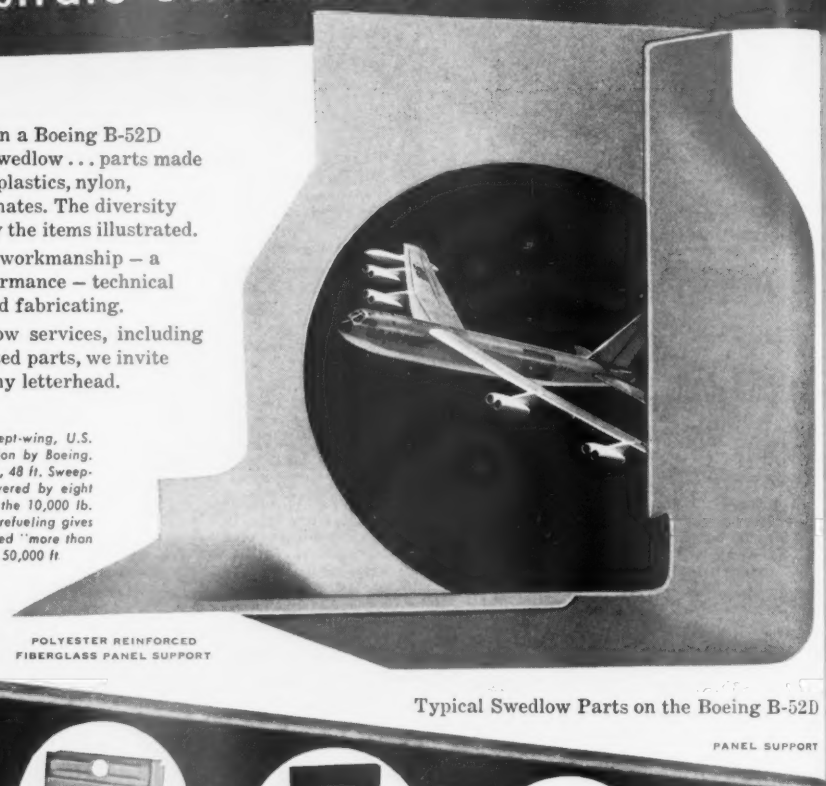

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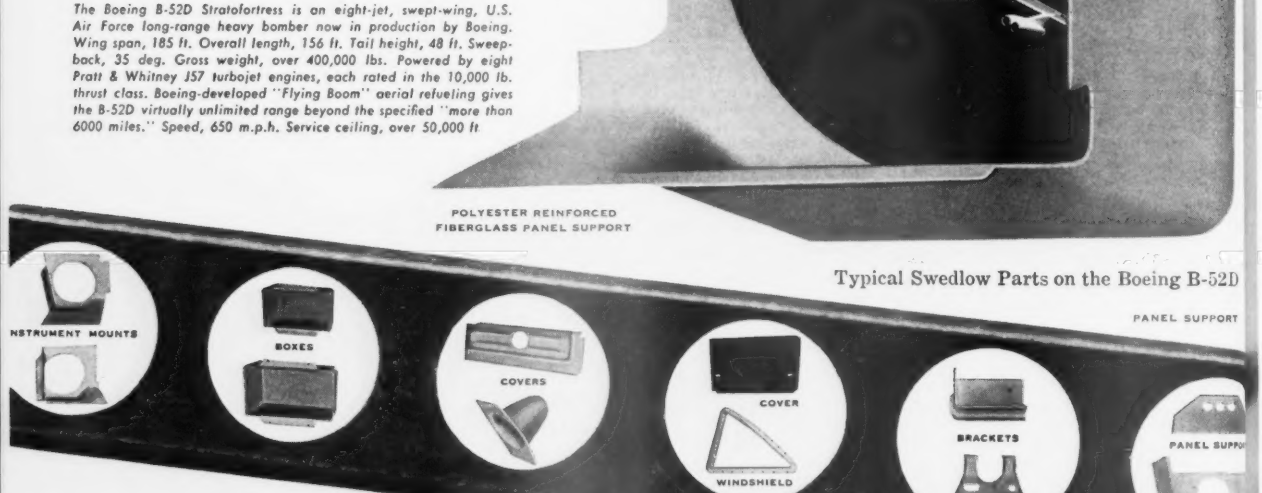

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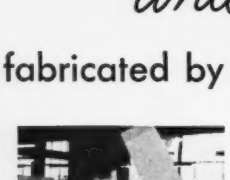

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CEC Recordings. Consolidated Electrodynamics Corp., 300 North Sierra Madre Villa, Pasadena, Calif., BM

Chartered Mech. Engr. The Chartered Mechanical Engineer; The Journal of the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London SW 1, England, 10 issues per year, £2. 5s. 6d.

Cienc. Aero. Ciencia Aeronáutica, Apartado de Correos 3879, Caracas, Venezuela, M, $4

Collins Signal. Collins Radio Company, Cedar Rapids, Iowa, Q

Comb. & Flame. Combustion and Flame. The Combustion Institute. Butterworths Scientific Publications, 4-5 Bell Yard, Temple Bar, London, WC 2, England; Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N.Y., Q, £5, 5s., $16

Commun. on Pure & Appl. Math. Communications on Pure and Applied Mathematics. Institute of Mathematical Sciences, New York University. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N.Y., Q, $8

Cook Tech. Rev. Cook Technical Review, Cook Electric Co., 2700 N. Southport Ave., Chicago 14, Ill., Irreg.

Data Processing Digest. Canning, Sisson, & Associates, 914 South Robertson Blvd., Los Angeles 35, Calif., M, $24

de Havilland Gazette. de Havilland Enterprise, Hatfield, Herts, England, Q

Des. News. Design News, 3375 S. Bannock, Englewood, Colo., SM, $20

Docaéro. Service de Documentation et d'Information Technique de l'Aéronautique (SDIT), 2, avenue de la Porte d'Issy, Paris 15, France, BM

Douglas Serv. Douglas Service. Douglas Aircraft Co., Inc., 3000 Ocean Park Blvd., Santa Monica, Calif., BM

Elec. Commun. Electrical Communication. International Telephone and Telegraph Corp., 67 Broad St., New York 4, N.Y., Q, $2

Elec. Energy. Electrical Energy, 28 Essex St., Strand, London WC 2, England, M, $5

Elec. Eng. Electrical Engineering. American Institute of Electrical Engineers, 33 W. 39 St., New York 18, N.Y., M, $12

Elec. Mfg. Electrical Manufacturing. 1250 6th Ave., New York 20, N.Y., M

Electronic & Radio Eng. Electronic & Radio Engineer, incorporating Wireless Engineer, Dorset House, Stamford St., London SE 1, England, M, $7.50

Electronic Appl. Rel. Rev. Electronic Applications Reliability Review. Radio-Electronics-Television Manufacturers Assn., 500 Fifth Ave., New York 36, N.Y., Irreg.

Electronic Des. Electronic Design, 19 E. 62 St., New York 21, N.Y., M

Electronic Eng. Electronic Engineering, 28 Essex St., Strand, London WC 2, England, M, $4

Electronic Ind. & Tele-Tech. Electronic Industries & Tele-Tech., 480 Lexington Ave., New York 17, N.Y., M, $5

Electronics, 330 W. 42 St., New York 36, N.Y., M, $6

Energetica si Hidrotehnica, str. Ioan Ghica 3, Bucarest, Rumania, M, lei 30

Eng. J. Engineering Journal. Engineering Institute of Canada, 2050 Mansfield St., Montreal, Canada, M, $6

The Engr. The Engineer, 28 Essex St., London WC 2, England, W, £5

Engr. Dig. The Engineers' Digest, 120 Wigmore St., London W1, England, M, $7.50

Environmental Quart. Environmental Quarterly. Institute of Environmental Engineers, Inc., and Environmental Equipment Institute, Inc., 9 Spring St., Princeton, N.J., Q, $4

Ericsson Tech. Ericsson Technics. Telefonaktiebolaget L.M. Ericsson, Stockholm 32, Sweden, SA

Escher Wyss News. Escher Wyss Engineering Works Ltd., Zurich, Switzerland, Irreg.

Esso Air Workl. Esso Export Corp., 60 W. 49 St., New York 20, N.Y., BM

Esso Aviation News Digest. Esso Export Corp., 45 Rockefeller Plaza, New York 21, N.Y., W

FAI Bul. Fedération Aéronautique Internationale, Bulletin, 6, rue Galilée, Paris, France, Q

FAI Circ. Inf. Fedération Aéronautique Internationale, Circulaire d'Information, 6, rue Galilée, Paris, France, Irreg.

Fasteners. Industrial Fasteners Institute, 1517 Terminal Tower, Cleveland 13, Ohio, Q

Flight, Dorset House, Stamford St., London SE 1, England, W, $14

Flight Control. Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N.J., M

Flight Mag. Flight Magazine, 2700 N. Haskell, Dallas, Tex., M, $3

Flug-Revue, Paulinenstrasse 44, Stuttgart, Germany, M, DM 25.20

Flugwehr und -Technik, 16 Promenadenstrasse Frauenfeld, Switzerland, M, 13 Sw. fr.

Flugwelt, Bahnhofstr. 61, Wiesbaden, Germany, M, DM 21.60

Flying, 366 Madison Ave., New York 17, N.Y., M, $4

Flying Safety. USAF Office of Flying Safety. Superintendent of Documents, Washington 25, D.C., M, $3

Forschung Gebiete Ing., Ausg. A. Forschung auf dem Gebiete des Ingenieurwesens, Ausgabe A. Verein deutscher Ingenieure, Bongardstr. 3, Düsseldorf, Germany, BM, DM 51

Franklin Inst. J. Franklin Institute, Journal, Parkway at 20 St., Phila. 3, Pa., M, $10

The Frontier. Armour Research Foundation, Illinois Institute of Technology, Technology Center, Chicago 16, Ill., Q

Fusées et Recherche Aéronautique. Association pour l'Encouragement à la Recherche Aéronautique, 1 rue de Courty, Paris 7, France, Q, 5,500 fr.

G-E Rev. General Electric Review. General Electric Co., Schenectady 5, N.Y., BM

Gen. Radio Exper. General Radio Experimenter. General Radio Company, 275 Mass. Ave., Cambridge 39, Mass., M

GM Eng. J. General Motors Engineering Journal. General Motors Technical Center, P.O. Box 177, North End Station, Detroit 2, Mich., BM

Grazhdanskaia Aviatsiia. Glavnoe Upravlenie Grazhdanskogo Vozdushnogo Flota, Moscow, U.S.S.R., M

Guild J. Guild Journal. The Guild of Air Pilots and Air Navigators of the British Empire, 19 Park Lane, London W 1, England, Q

Handley-Page Bul. Handley-Page Bulletin. Handley-Page Ltd., London NW 2, England, Q

Hawker Siddeley Rev. Hawker Siddeley Review. Hawker Siddeley Group Ltd., 18 St. James's Square, London, SW 1, England, Q

Helicopter Assn. Gt. Brit. J. Helicopter Assn. of Gt. Britain, Journal, 4, The Sanctuary, Westminister, London SW 1, England, Q

Hokkaidô Gakugei U. J. Sect. B. Hokkaidô Gakugei University, Journal, Section B, Sapporo, Japan, Q

Honeywell Flight Lines. Aeronautical Division, Minneapolis-Honeywell Regulator Co., 2600 Ridgeway Road, Minneapolis 13, Minn., BM

Hosei U. Tech. Coll. Rep. Hosei University, Technical College, Reports, 7 Sinborityo, Azabu, Minato-ku, Tokyo, Japan, Irreg.

Hunting Group Rev. Hunting Group Review, 4 Dunraven St., Park Lane, London W 1, England, Q

Hydraulic Engr. Hydraulic Engineer. Electrol Inc., 85 Grand St., Kingston, N.Y., BM

IATA Bul. IATA Bulletin. International Air Transport Assn., International Aviation Bldg., 1080 University St., Montreal 3, Canada, SA, $3.75

IBM J. Res. & Devel. IBM Journal of Research and Development. International Business Machines Corp., 590 Madison Ave., New York 22, N.Y., Q, $3.50

ICAO Bul. ICAO Bulletin. International Civil Aviation Organization, International Aviation Bldg., 1080 University St., Montreal 3, Canada, M, $2

IEE Proc. B. Institution of Electrical Engineers, Proceedings, Part B, Savoy Place, London WC 2, England, BM, £2 5s.

Ilmailu, Mannerheimintie 16-A, Helsinki, Finland, M, Fmk. 600

IME Proc. Institution of Mechanical Engineers, Proceedings, 1 Birdcage Walk, Westminster, London SW 1, England, Irreg.

Ind. & Eng. Chem. Industrial and Engineering Chemistry. American Chemical Society, 1155 16th St., NW, Washington 6, D.C., M, $4.50

Ind. Labs. Industrial Laboratories, 201 N. Wells St., Chicago 6, Ill., M

Ind. Quality Control. Industrial Quality Control. American Society for Quality Control, Inc., Room 6197, 161 W. Wisconsin Ave., Milwaukee 3, Wis., M, $9

Ind. Res. Newsletter. Industrial Research Newsletter. Armour Research Foundation, Illinois Institute of Technology, Technology Center, Chicago 16, Ill., M

Ind. Sci. & Eng. Industrial Science and Engineering, 201 N. Wells St., Chicago 6, Ill., BM

Indian AF Quart. Indian Air Force Quarterly. Directorate of Training, Air HQ, New Delhi, India, Q

Indian Airman, Roy Mansions, Behala, Calcutta 34, India, M, 10 Rupees

Indian Inst. Sci. J. Indian Institute of Science, Journal, Bangalore 3, India, M, $6.50

Indian Skyways, Gandhigram Road, Juhu, Bombay 23, India, M, 20 Rupees

Info. & Control. Information and Control, 111 5th Ave., New York 3, N.Y., Q, $10

Informations Aéronautiques. Union Syndicale des Industries Aéronautiques, 4 rue Galilée, Paris 16, France, W

Ing.-Arch. Ingenieur-Archiv. Neuenheimer Landstr. 24, Heidelberg, Germany, BM

Inst. Electronics Proc. Institute of Electronics, Proceedings, 5 Baron Place, London SE 1, England, Irreg.

Inst. Navigation J. Institute of Navigation, Journal, 1 Kensington Gore, London SW 7, England, Q, $6

Inst. Roy. Météor. Belg. Bul. Institut Royal Météorologique de Belgique, Bulletin, Uccle, Brabant, Belgium, Irreg.

Inst. Transp. J. Institute of Transport, Journal, 80 Portland Place, London W 1, England, BM, 21s.

Instrumentation. Industrial Division, Minneapolis-Honeywell Regulator Co., Wayne & Windrim Aves., Philadelphia 44, Pa., BM

Instruments and Automation, 1600 N. Main St., Pontiac, Ill., M, $4

Interavia, 6 Corraterie, Geneva, Switzerland, M, $7

IRE. Proc. Institute of Radio Engineers, Proceedings, 1 E. 79 St., New York 21, N.Y., M, $18

IRE Trans. Institute of Radio Engineers, Transactions, 2 E. 79th St., New York 21, N.Y.
- **ANE.** Aeronautical and Navigational Electronics, Q, $17
- **AP.** Antennas and Propagation, Q, $17
- **CS.** Communications Systems, Q, $17
- **EC.** Electronic Computers, Q, $17

ISA J. Instrument Society of America, Journal, 1319 Allegheny Ave., Pittsburgh 33, Pa., M, $4

Istanbul Tek. U. Bul. Istanbul Teknik Üniversitesi, Bülteni, Istanbul, Turkey, Annually

Izmer. Tekh. Izmeritel'naia Tekhnika. Komitet Standartov, Mer i Izmeritel'nykh Priborov, Moscow, U.S.S.R., BM

J. Aero. Sci. Journal of the Aeronautical Sciences. Institute of the Aeronautical Sciences, Inc., 2 East 64th St., New York 21, N.Y., M, $15

J. Air Law & Commerce. Journal of Air Law & Commerce. Northwestern University, Chicago 11, Ill., Q, $6

J. Appl. Mech. Journal of Applied Mechanics. American Society of Mechnical Engineers, 29 W. 39 St., New York 18, N.Y., Q, $5

J. Appl. Phys. Journal of Applied Physics. American Institute of Physics, 57 E. 55 St., New York 22, N.Y., M, $12

J. Astronautics. Journal of Astronautics. American Astronautical Society, 516 Fifth Ave., New York 36, N.Y., Q, $6

J. Atmos. & Terrestrial Phys. Journal of Atmospheric and Terrestrial Physics, 4 Fitzroy Square, London W1, England; 122 E. 55th St., New York 22, N.Y., BM, $14

J. Av. Med. Journal of Aviation Medicine. Aero Medical Assn., 2642 University Ave., St. Paul 14, Minn., BM, $7.50

J. Eng. Educ. Journal of Engineering Education. American Society for Engineering Education, University of Illinois, Urbana, Ill., M, $6

J. Fluid Mech. Journal of Fluid Mechanics, Taylor & Francis Ltd., Red Lion Court, Fleet St., London EC 4, England; Academic Press, Inc., 111 5th Ave., New York 3, N.Y., BM, £5. 10s., $16.50

J. Math. & Mech. Journal of Mathematics & Mechanics. Graduate Institute for Applied Mathematics, University of Indiana, Bloomington, Ind., BM, $18

J. Math. & Phys. Journal of Mathematics and Physics. MIT, Cambridge 39, Mass., Q, $6

J. Mech. & Phys. Solids. Journal of the Mechanics and Physics of Solids, 4 Fitzroy Square, London W 1, England; 122 E. 55th St., New York 22, N.Y., Q, $12.60

J. Meteorology. Journal of Meteorology. American Meteorological Society, 3 Joy St., Boston 8, Mass., BM, $9.50

J. Res. Journal of Research. U.S. National Bureau of Standards. Supt. of Documents, Washington 25, D.C., M, $4

J. Sci. & Ind. Res. Journal of Scientific & Industrial Research. Council of Scientific & Industrial Research, 20 Pusa Road, New Delhi 5, India, 15 Rupees

J. Sci. Instr. Journal of Scientific Instruments. Institute of Physics, 47 Belgrave Square, London SW 1, England, M. £5

J. Space Flight. Journal of Space Flight (including the Rocket Newsletter). Chicago Rocket Society, 948 119 St., Whiting, Ind., M. $6

J. Tech. Journal of Technology, Bengal Engineering College, Superintendent—Govt. Printing, Calcutta, India, SA, $2.50

Japan Sci. Rev. Mech. & Elec. Eng. The Japan Science Review, Mechanical & Electrical Engineering. Japan Society of Mechanical Engineers (with cooperation of allied engineering societies and associations), Maro-

nouchi Bldg., Chiyoda-Ku, Tokyo, Japan, SA, $2

Japan Soc. Aero. Eng. J. Japan Society of Aeronautical Engineering, Journal, Kikokwan No. 3, 1-chome, Shiba-Tamura-cho, Minato-ku, Tokyo, Japan, M

Jet Age. A. V. Roe, Ltd., P.O. Box 430, Toronto, Ontario, Canada, Q

Jet Propulsion. American Rocket Society, 500 Fifth Avenue, New York 36, N.Y., M, $12.50

Joint Services Recognition Journal. Air Ministry, Richmond Terrace, Whitehall, London SW 1, England, M

Kyushu U., Rep. Res. Inst. Appl. Mech. Kyushu University, Research Institute for Applied Mechanics, Reports, Fukuoka, Japan, SA

Light Metals, Bowling Green Lane, London EC 1, England, M, 26s.

Lockheed Field Serv. Dig. Lockheed Field Service Digest. Lockheed Aircraft Corp., Burbank, Calif., BM

The Log. British Air Line Pilots Assn., 95 Mount St., London W 1, England, M

Lond. Math. Soc. Proc. London Mathematical Society, Proceedings, Amen House, London EC 4, England, Q, £4

Lubrication. The Texas Co., 135 E. 42nd St., New York 17, N.Y., M

Lubrication Eng. Lubrication Engineering, American Society of Lubrication Engineers, 84 E. Randolph St., Chicago 1, Ill., M, $6

Luftfahrttechnik. Verein deutscher Ingenieure, Bongardstr. 3, Düsseldorf, Germany, M, DM 43.50

Mach. Des. Machine Design, Cleveland 13, Ohio, BW, $10

Mag. of Magnesium. Magazine of Magnesium, Brooks & Perkins, Inc., 1950 Fort St., Detroit 16, Mich., Q

Mag. of Standards. Magazine of Standards, American Standards Assn., Inc., 70 E. 45 St., New York 17, N.Y., M, $7

Marconi Rev. The Marconi Review. Marconi's Wireless Telegraph Co. Ltd., Chelmsford, England, Q

Materials & Methods, 430 Park Ave., New York 22, N.Y., M, $2

MATS Flyer. Military Air Transport Service. Supt. of Documents, Washington 25, D.C., M, $2.25.

Mech. Eng. Mechanical Engineering. American Society of Mechanical Engineers, 29 W. 39 St., New York 18, N.Y., M, $7

Mechanika. Central Library, Polytechnic School, 155 Gdanska, Lodz, Poland, Irreg.

Metal Treat. Metal Treatment and Drop Forging, 17–19 John Adam St., Adelphi, London WC 2, England, M, 30s.

Metallurgia, 31 King St. W., Manchester 3, England, M, 24s.

Meteor. Abs. & Bibliog. Meteorological Abstracts and Bibliography. American Meteorological Society, 3 Joy St., Boston 8, Mass., M, $8

Meteorological Mag. The Meteorological Magazine, Air Ministry Meteorological Office, British Information Services, 45 Rockefeller Plaza, New York 20, N.Y., M, $4

Meteoros. Servicio Meteorológico Nacional, Buenos Aires, Argentina, Q, 40 pesos

Mil. Med. Military Medicine. Assn. of Military Surgeons, 1726 Eye Street, NW, Washington, D.C., M, $7.50

Military Aircraft Data Sheets. Aviation Studies (International) Ltd., 29–31 Cheval Place, Knightsbridge, London SW 7, England, Q, £2

Missiles & Rockets, 1001 Vermont Avenue, NW, Washington 5, D.C., M, $8

Mo. Weather Rev. Monthly Weather Review. U.S. Weather Bureau. Supt. of Documents Washington 25, D.C., M, $3

Nav. Res. Logistics Quart. Naval Research Logistics Quarterly. Office of Naval Research. Superintendent of Documents Washington 25, D.C., Q, $1.50

Naval Av. News. Naval Aviation News. Chief of Naval Operations and Bureau of Aeronautics. Superintendent of Documents, Washington 25, D.C., M, $2

Navigation. Institute of Navigation, University of California, 405 Hilgard Ave., Los Angeles 24, Calif., Q, $10

News Eng. News in Engineering. Engineering Experiment Station, Ohio State University, Columbus 10, Ohio, Q, $1

News Report, National Academy of Sciences. National Research Council, 2101 Constitution Ave., Washington 25, D.C., BM, $2

Noise Control. Acoustical Society of America, 57 East 55 St., New York 22, N.Y., BM, $8

Notiz. Av. Notiziario de Aviazione. Ufficio del Segretario Generale, Ministero della Difesa—Aeronautica, Rome, Italy, M

Nuclear Eng. Nuclear Engineering, Bowling Green Lane, London EC 1, England, M, $7

Official Air Line Guide, 1001 Vermont Ave., NW, Washington 5, D.C., M, $13.50

Oper. Res. Operations Research. Operations Research Society of America, Mt. Royal & Guilford Aves., Baltimore 2, Md., BM, $7.50

Ordnance. American Ordnance Assn., 708 Mills Bldg., Washington 6, D.C., BM, $4.50

Pacific J. Math. Pacific Journal of Mathematics Univ. of California Press, Berkeley 4, Calif., Q, $12

Papers in Meteorology & Geophys. Papers in Meteorology and Geophysics. Meteorological Research Institute, Mabashi, Suginami, Tokyo, Japan, Irreg.

Pegasus. Fairchild Engine and Airplane Corp., Hagerstown, Md., M

Philips Tech. Rev. Philips Technical Review. N.V. Philips Co., Eindhoven, Netherlands, M, $5

Philos. Mag. The Philosophical Magazine, Red Lion Court, Fleet St., London EC 4, England, M, £8

Photogrammetric Eng. Photogrammetric Engineering, American Society of Photogrammetry, 1515 Massachusetts Ave., NW, Washington 5, D.C., 5 issues per year, $6

Photographic Eng. Photographic Engineering. Society of Photographic Engineers, Box 6077, Mid-City Sta., Washington 5, D.C., Q, $8

Phys. Soc. Japan J. Physical Society of Japan, Journal, Dept. of Physics, Faculty of Science, University of Tokyo, Bunkyo-ku, Tokyo, Japan, M, $5

Planes. Aircraft Industries Assn. of America, 610 Shoreham Bldg., Washington 5, D.C., M

Pol. Inst. Lot. Prace. Poland, Instytut Lotnictwa, Prace. Ministerstwo Przemysu Maszynowego, Warsaw, Poland, Irreg.

Prikl. Mat. i Mekh. Prikladnaia Matematika i Mekhanika, Akademiia Nauk SSSR, Moscow, USSR, BM

Prod. Eng. Product Engineering, 330 W. 42 St., New York 36, N.Y., M, $5

Project Engr. Project Engineer. The Thermix Corp., Greenwich, Conn., M

Propel, Mariagervej 4, Helsingor, Denmark, M

Protar, Solothurn, Switzerland, BM, 15 Sw. fr.

Quart. Appl. Math. Quarterly of Applied Mathematics. Brown University, Providence 12, R.I., Q, $6

Quart. J. Mech. & Appl. Math. Quarterly Journal of Mechanics and Applied Mathematics, Amen House, London EC 4, England, Q, 60s.

RCA Rev. RCA Review. RCA Laboratories, Radio Corporation of America, Princeton, N.J., Q, $2

RAeS J. Royal Aeronautical Society, Journal, 4 Hamilton Place, London W 1, England, M, £ 10s. 6d.

Raketentech. & Raumfahrtforsch. Raketentechnik und Raumfahrtforschung. Deutsche Gesellschaft für Raketentechnik und Raumfahrt, Neuensteiner Strasse 19, Stuttgart-Zuffenhausen, Germany, Irreg., $1 per issue

Rec. Ocean. Works Japan. Records of Oceanographic Works in Japan. Japanese National Commission for UNESCO, 4-3 Kasumigasiki, Chiyoda-ku, Tokyo, Japan, Irreg.

La Recherche Aéronautique. Office National d'Etudes et de Recherches Aéronautiques (ONERA), 29 ave. de la Division-Leclerc, Chatillon-sous-Bagneux (Seine), France, BM, 4,300 fr.

Repüles, Engels tér 14, Budapest 5, Hungary, M, 48 ft.

Res. Rev. Research Reviews. Office of Naval Research, Department of the Navy. Supt. of Documents, Washington 25, D.C., M, $1.50

Res. Trends. Research Trends. Cornell Aeronautical Laboratory, Inc., 4455 Genessee St., Buffalo 21, N.Y., Q

Rev. Aero. Revista de Aeronáutica. Ministro del Aire, 8 Romero Robledo, Madrid, Spain, M, 90 pesetas

Rev. Math. Pures & Appl. Revue de Mathématiques Pures et Appliquées. Académie de la Republique Populaire Roumaine, 125, Calea Victoriei, Bucarest, Rumania, Irreg.

Rev. Méc. Appl. Revue de Méchanique Appliquée. Institut de Mécanique Appliquée, Académie de la Republique Populaire Roumaine, 15 rue C. Mille, Bucarest, Rumania, Irreg.

Rev. Nac. Aero. Revista Nacional de Aeronáutica, 741 Ave. Cordoba, Buenos Aires, Argentina, M, $6

Rev. Phys. Revue de Physique, Academia Republicii Populare Romine, Bucarest, Rumania, Irreg.

Rev. Sci. Instr. Review of Scientific Instruments. American Institute of Physics, 57 E. 55 St., New York 22, N.Y., M, $9

Rev. Sci. Tech. Revue des Sciences Techniques. Académie de la Republique Populaire Roumaine, 125, Calea Victoriei, Bucarest, Rumania, Irreg.

Rev. SNCASO. Revue SNCASO. Société Nationale de Constructions Aéronautiques du Sud-Ouest, avenue Raymond Poincaré 105, Paris 16, France, Q

Rev. Transp. Revista Transporturilor, Str. Ioan Ghica 3, Bucarest, Rumania, M, lei 30

Riv. Aero. Rivista Aeronautica. Ministero Difesa—Aeronautica, viale dell'Universitá 4, Rome, Italy, M, $7

Riv. Med. Aero. Rivista di Medicina Aeronautica, via P. Gobetti 2, Rome, Italy, Q, L. 3,600

Riv. Meteorologia Aero. Rivista di Meteorologia Aeronautica. Servizio Meteorologico d'Aeronautica, via San Vincenzo di Paoli 11, Rome, Italy, Q, L. 3,000

Royal Soc. Edin. Proc. A. Royal Society of Edinburgh, Proceedings, Section A, Mathematical and Physical Sciences, 22 George St., Edinburgh 2, Scotland, Irreg.

Royal Soc. (London) Philos. Trans. Ser. A. Royal Society (London), Philosophical Transactions, Series A, Mathematical and Physical Sciences, Burlington House, Piccadilly, London W 1, England, Irreg., £9 9s.

Royal Soc. (London) Proc. Ser. A. Royal Society (London), Proceedings, Series A, Mathematical and Physical Sciences, Burlington House, Piccadilly, London W 1, England, Irreg.

Rozprawy Inzynierskie. Polska Akademia Nauk, ul. Nowy Swiat 72, Warsaw, Poland, Q, 80 zl.

Ryan Reporter. Ryan Aeronautical Co., P.O. Box 311, San Diego 12, Calif.

Saab Sonics. Saab Aircraft Co., Linköping, Sweden, Irreg.

SAE J. Society of Automotive Engineers, Journal, 485 Lex. Ave., New York 17, N.Y., M, $10

Safety News Letter, Air Transp. Sect. Safety News Letter, Air Transport Section. National Safety Council, Chicago 11, Illinois, M

Sailplane and Glider, 8 Lower Belgrave St., London SW 1, England, BM, 12s. 9d.

Saro Prog. Saro Progress. Saunders-Roe Ltd., East Cowes, Isle of Wight, England, Q

SBAC Press Summary. Society of British Aircraft Constructors, 29 King St., St. James's, London SW 1, England, W

Schw. Aero-Rev. Schweizer Aero-Revue. Aero-Club der Schweiz, Hirschengraben 22, Zurich, Switzerland, M, 18 Sw. fr.

Sci. Mo. The Scientific Monthly. American Assn. for the Advancement of Science, 1515 Mass. Ave., NW, Washington 5, D.C., M, $7.50

Science. American Assn. for the Advancement of Science, 1515 Mass. Ave., NW, Washington 5, D.C., W, $7.50

Ser. Selec. Papers Phys. Series of Selected Papers in Physics. Physical Society of Japan, Dept. of Physics, Faculty of Science, University of Tokyo, Bunkyo, Tokyo, Japan, Irreg.

Shell Av. News. Shell Aviation News. Aviation Dept., Shell Oil Co., 50 W. 50 St., New York 20, N.Y., M

Sky & Tel. Sky & Telescope, Harvard College Observatory, 60 Garden St., Cambridge 38, Mass., M, $5

Skyline. North American Aviation, Inc., International Airport, Los Angeles 45, Calif., Q

Skyways, 122 E. 42 St., New York, N.Y., M, $4

SLAE J. Society of Licensed Aircraft Engineers, Journal (incorporating The Technical Instructor), 1 High St., Maidenhead, Berkshire, England, M, 30s.

So. Afr. Interpl. Soc. J. South African Interplanetary Society, Journal, P.O. Box 2330, Johannesburg, Union of South Africa, Q, 10s.

Soaring. Soaring Society of America and the Soaring Assn. of Canada, P.O. Box 71, Elmira, N.Y.; Ferguson Rd., Dallas 28, Tex., BM, $4

Soc. Inst. Tech. Trans. Society of Instrument Technology, Transactions, 4, Grosvenor Gardens, London SW 1, England, Q, £2 10s.

Solar Blast. Solar Aircraft Co., San Diego 12, Calif., Q

Sov. Phys.—Acous. Soviet Physics—Acoustics, American Institute of Physics, 57 E. 55 St. New York 22, N.Y., Q, $20

Sov. Phys.—Dokl. Soviet Physics—Doklady (Physics Section), American Institute of Physics, 57 E. 55 St., New York 22, N.Y., BM, $25

Sov. Phys.—JETP. Soviet Physics—JETP (Journal of Experimental and Theoretical Physics), American Institute of Physics, 57 E. 55 St., New York 22, N.Y., M, $64

Sov. Phys.—Tech. Phys. Soviet Physics—Technical Physics, American Institute of Physics, 57 E. 55 St., New York 22, N.Y., M, $90

Spaceflight. British Interplanetary Society, 12 Bessborough Gardens, London SW 1, England, Q

SPE J. Society of Plastic Engineers, Journal, 35 East Putnam Ave., Greenwich, Conn., M, $4

Sperry Eng. Rev. Sperry Engineering Review, Sperry Gyroscope Co., Great Neck, N.Y., BM

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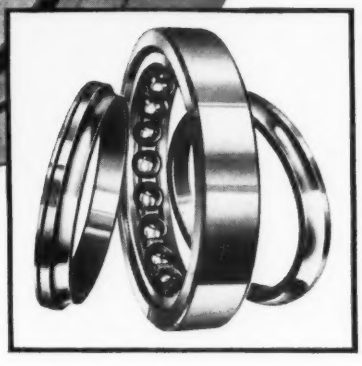

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Sperry Rev. The Sperry Review. The Sperry Gyroscope Co., Ltd., Great West Road, Brentford, Middlesex, England, SA

Sperryscope. Sperry Rand Corp., 30 Rockefeller Plaza, New York 20, N.Y., Q

SRI J. Stanford Research Institute, Journal, Menlo Park, Calif., Q, $4

Steel Processing & Conversion, 624 Grant Bldg., Pittsburgh 30, Pa., M, $2.50

Strojniski Vestnik. Aškerčeva 28, Ljubljana, Yugoslavia, Q, 520 din

Stud. Cerc. Mec. Aplic. Studii si Cercetari de Mecanica Aplicata. Academia Republicii Populare Romine, Bucarest, Rumania, Q

Stud. Cerc. Stiint. Studii si Cercetari Stiintifice. Academia Republicii Populare Romine, Bucarest, Rumania, Q

Sylvania Technologist. Sylvania Electric Products, Inc., Bayside, N.Y., Q, $1.50

Taylor Tech. Taylor Technology. Taylor Instrument Companies, Rochester 1, N.Y., Q

Tec. Ital. Technica Italiana. Consiglio Nazionale delle Ricerche, via Beccaria 6, Trieste, Italy, M, L. 6,000

Tech. et Sci. Aéronautiques. Technique et Science Aéronautiques. Assn. Française des Ingénieurs et Techniciens de l'Aéronautique (AFITA), 6 rue Cimarosa, Paris 16, France, BM

Tech. Lotnicza. Technika Lotnicza, Nowowiejska 24, Warsaw 10, Poland, BM, 54 zl.

Tech. News Bull. Technical News Bulletin. U.S. National Bureau of Standards. Supt. of Documents, Washington 25, D.C., M, $1

Tech. Rev. The Technology Review. MIT, Cambridge 39, Mass., M, $4

Tek. Tidsk. Teknisk Tidskrift. Svenska Teknologföreningen, Box 841, Stockholm 1, Sweden, W, 50 kr.

Tex. Eng. Exp. Sta. News. Texas Engineering Experiment Station News, College Station, Tex., Q

Thermik, Obere Maschstrasse 8, Göttingen, Germany, M, DM 10

Thompson Prod. Eng. Bul. Thompson Products Engineering Bulletin. Thompson Products, Inc., 23555 Euclid Ave., Cleveland 17, Ohio, Irreg.

Tôhoku U. Rep. Inst. High Speed Mech. Tôhoku University, Institute of High Speed Mechanics, Reports, Sendai, Japan

Tool Engr. Tool Engineer. American Society of Tool Engineers, 10700 Puritan Ave., Detroit 38, Mich., M, $6

Trend in Eng. The Trend in Engineering. Engineering Experiment Station, University of Washington, Seattle 5, Wash., Q

U.S. Air Serv. U.S. Air Services, Transportation Bldg., Washington 6, D.C., M, $3

U.S. Nav. Inst. Proc. United States Naval Institute, Proceedings, Annapolis, Md., M, $3

VDI-Zeitschrift. Verein deutscher Ingenieure, Bongardstrasse 3, Dusseldorf, Germany, 3 issues per month, DM 60

Vickers Mag. Vickers, Ltd., Vickers House, London SW 1, England, SA

Vitesse-Speed, 28, rue Vaneau, Paris 7, France, M

De Vliegende Hollander. Royal Netherlands Air Force, Gevers Deynootplein 5, Scheveningen, Netherlands, M, 5.50 fl.

W. U. Tech. Rev. Western Union Technical Review. Western Union Telegraph Co., 60 Hudson St., New York 13, N.Y., Q, $1.50

Wasserwirtschaft, Pfizerstrasse 5-7, Stuttgart, Germany, M, DM 30

Welding J. Welding Journal. American Welding Society, 33 W. 39 St., New York 18, N.Y., M, $7

Weltraumfahrt, Stuttgarterstr. 20, Frankfurt a.M., Germany, Q, DM 9.84

Western Av. Western Aviation, 4328 Sunset Blvd., Los Angeles 29, Calif., M, $3

Westinghouse Engr. Westinghouse Engineer. Westinghouse Electric Corp., P.O. Box 2278, 3 Gateway Center, Pittsburgh 30, Pa., BM, $2.50

Whites Av. Whites Aviation, Dilworth Bldg., Queen St., Auckland, New Zealand, M, $3

Wings. Royal New Zealand Aero Club, Inc., 1 Marion St., Wellington, N.Z., M, 15s.

Wireless Engr. Wireless Engineer, Dorset House, Stamford St., London SE 1, England, M, $7.50

Wireless World, Dorset House, Stamford St., London SE 1, England, M, $5

WMO Bul. WMO Bulletin. World Meteorological Organization, Campagne Rigot, ave. de la Paix, Geneva, Switzerland, Q, 4 Sw. fr.

ZAMM. Zeitschrift für angewandte Mathematik und Mechanik, Mohrenstr. 39, Berlin W8, Germany, M, DM 60

ZAMP. Zeitschrift für angewandte Mathematik und Physik, Basel 10, Switzerland, BM, 48 Sw. fr.

ZFW. Zeitschrift für Flugwissenschaften. Wissenschaftliche Gesellschaft für Luftfahrt e.V. (WGL), Burgplatz 1, Braunschweig, Germany, M, DM 48

Acoustics, Sound, & Noise

Propagation of Sound Into a Wind-Created Shadow Zone. Appendix A—Ray Acoustics in a Wind Gradient. David C. Pridmore-Brown. *U.S., NACA Rep. RM 57B25,* Apr. 22, 1957. 25 pp. Derivation of a general wave equation governing the propagation of sound in a stratified moving medium, the velocity of which varies only along one coordinate.

Aerodynamics

Applying the Jet Flap. David W. H. Godfrey. *The Aeroplane,* Apr. 12, 1957, pp. 511–513. Review of the development work on the jet flap, discussion of the basic principles, and applications to aircraft.

Low Speed Wind Tunnel Tests on Perforated Square Flat Plates Normal to the Airstream: Drag and Velocity Fluctuation Measurements. B. G. de Bray. (*Gt. Brit., RAE TN Aero.2475,* Oct., 1956). *Gt. Brit., ARC CP 323,* 1957. 13 pp. BIS, New York, $0.45.

The Effect of Flexibility on the Drag Polar of an Aircraft. W. P. Rodden, T. E. Surber, and H. C. Vetter. *J. Aero. Sci.,* June, 1957, pp. 456–458. Analysis which indicates that neglecting the effects of flexibility on the trimmed drag polar is only justified for slightly swept wings.

Vortex Interference Effects on the Aerodynamics of Slender Airplanes and Missiles. Alvin H. Sacks. (*IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 688.*) *J. Aero. Sci.,* June, 1957, pp. 393–402, 412. 18 refs. Description of a method for calculating the vortex strengths and positions at the tail and, particularly, the corresponding forces and moments due to vortex interference.

Aerothermodynamics

Aerodynamische Erwärmung-die Hitzeschwelle in der Luftfahrt. Theodore von Kármán. *Flugwelt,* Mar., 1957, pp. 163–164. In German. Analysis of aerodynamic heating in terms of heat transfer, heat conduction, and cooling methods.

Note on the Aerodynamic Heating of an Oscillating Insulated Surface. Stephen H. Maslen and Simon Ostrach. *Quart. Appl. Math.,* Apr., 1957, pp. 98–101. Analysis of a doubly infinite plane surface which is oscillating axially in a viscous and heat-conducting fluid, to determine the effect of insulating the surface, at a given time, on the equilibrium state.

A New Technique for Investigating Heat Transfer and Surface Phenomena Under Hypersonic Flow Conditions. Antonio Ferri and Paul A. Libby. *J. Aero. Sci.,* June, 1957, pp. 464, 465. Description of the shrouded-model technique.

Normal Conduction Effects on Heat-Transfer Data During Transient Heating of Thin-Skin Models. Morton Cooper and Edward E. Mayo. *J. Aero. Sci.,* June, 1957, pp. 461, 462. Analysis of heating in thin-skin structures to establish the magnitude of the error involved by neglecting the presence of a fill material to show that, even for the best of fill materials, the errors might be significant.

Free Molecular Flow Forces and Heat Transfer for an Infinite Circular Cylinder at Angle of Attack. L. Talbot. *J. Aero. Sci.,* June, 1957, pp. 458, 459. OSR-ONR-supported research.

Tables of Various Mach Number Functions for Specific-Heat Ratios From 1.28 to 1.38. *U.S., NACA TN 3981,* Apr., 1957. 76 pp.

Boundary Layer

Boundary Layer Stabilization by Distributed Damping. Max O. Kramer. *J. Aero. Sci.,* June, 1957, pp. 459, 460. Experimental investigation which shows the relative increase of the transition Reynolds Number in the center of the cylindrical wall as a function of the two main parameters of the damping rubber lining—the resistivity and the resiliency.

Note on the Boundary-Layer Instability on a Flat Plate Stopped Suddenly. Francis R. Hama. *J. Aero Sci.,* June, 1957, pp. 471, 472. OSR-supported discussion of the stability of a two-dimensional negative vortex under three-dimensional disturbances with emphasis on the deceleration of a flat plate. It is shown that the boundary layer is unstable in the deceleration stage but that the instability is harmless and will not cause transition.

Some New Conceptions of the Mechanism of Stall in Turbulent Boundary Layers. Stephen J. Kline. *J. Aero. Sci.,* June, 1957, pp. 470, 471. Discussion which concludes that the inception of stall is usually a three-dimensional transient phenomenon which is called transitory stall. The transitory spots of stall are viewed as a mechanism that is adapted by the fluid to supply the energy needed by the very slow moving layers near the wall in order to negotiate adverse pressure gradient.

Fluid Mechanics & Aerodynamic Theory

Calculation of Axially Symmetric Cavities and Jets. P. R. Garabedian. *Pacific J. Math.,* Winter, 1956, pp. 611–684. 18 refs. Theoretical investigation of steady, axially symmetric, irrotational flows of an incompressible liquid for the purpose of deriving systematic calculation techniques for free surface flows. The mathematical theory of cavities and jets is extended to obtain numerical results.

On the Pressure Losses for Turbulent Flow in Smooth Pipe Bends. II. H. Ito. *Tôhoku U., Rep. Inst. High Speed Mech.,* vol. 7, 1956, pp. 149–174. 18 refs. Theoretical investigation to derive a formula, based on the logarithmic velocity-distribution law, which is valid for Reynolds Numbers above 2×10^6. A method is found for deriving the characteristic dimensionless variables, including the Dean Number in the case of laminar flow, which determine the influence of curvature for flow in curved pipes.

La Perturbation de l'Écoulement Moléculaire Libre Produite par un Obstacle. M. Łunc and J. Luboński. *Bul. Acad. Polonaise Sci.,* No. 1, 1957, pp. 47–57. In French. Development of an approxi-

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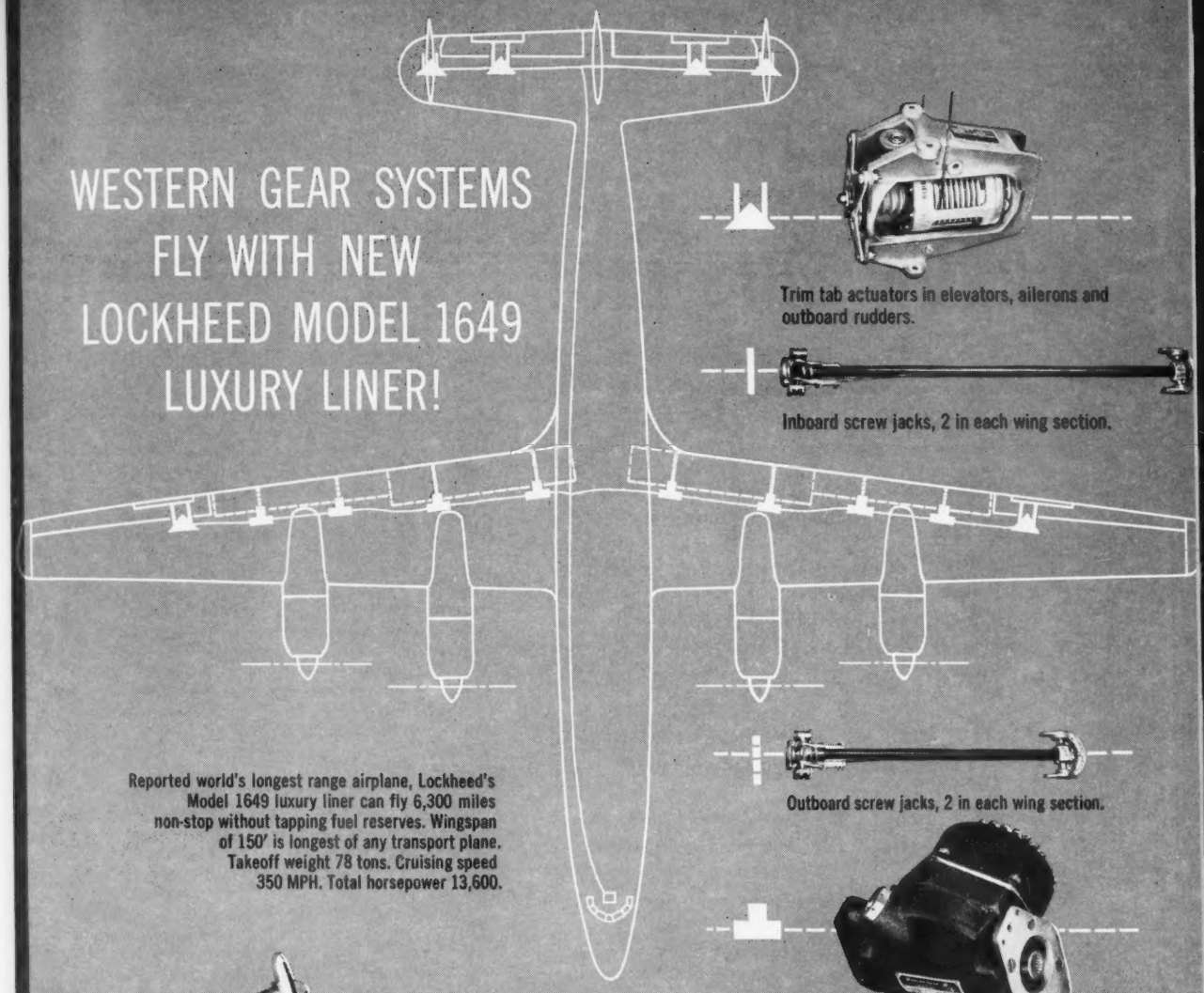

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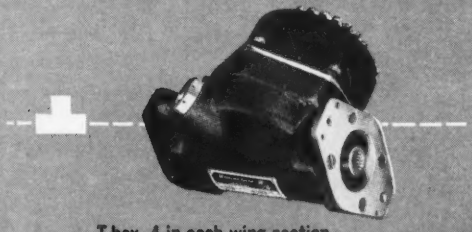

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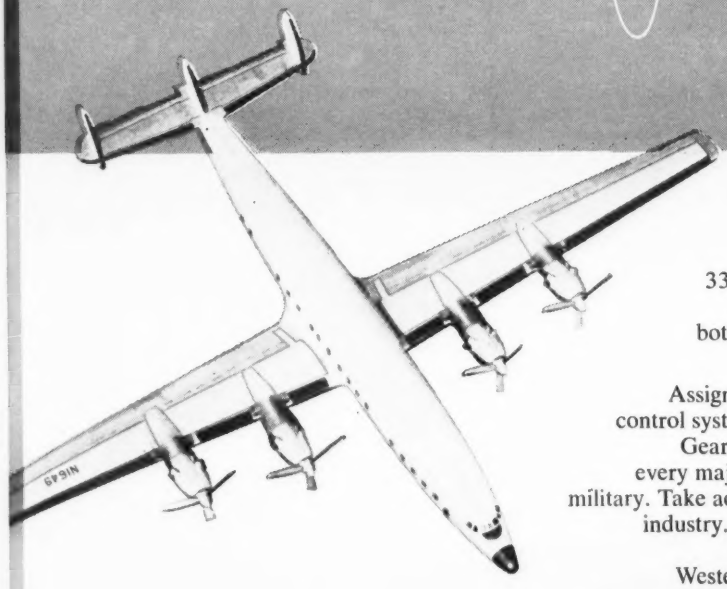

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Newtonian Flow Theory for Slender Bodies. J. D. Cole. (*RAND Corp. Rep. P-926*, Sept. 28, 1956). *J. Aero. Sci.*, June, 1957, pp. 448–455. 10 refs. Analysis of Newtonian flow theory, in terms of gas dynamics and hypersonic small-disturbance theory, in order to aid the aerodynamicist in the design of air frames for hypersonic speeds.

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A Note on the Solution of a Non-Linear Transonic Flow Equation. John T. Robacker and Albert D. Wheelon. *J. Math. & Phys.*, Oct., 1956, pp. 321, 322. Method for systematically generating particular solutions for the nonlinear term of the transonic equations.

Note on the Turbulent Shear Stress Near a Wall. H. G. Elrod, Jr. *J. Aero. Sci.*, June, 1957, pp. 468, 469. Analysis to show the manner in which the turbulent contribution to shear stress vanishes in the neighborhood of a wall bounding the two-dimensional established flow of an incompressible fluid.

Internal Flow

Slow Viscous Flow Within Circular Cylinders. D. G. Mabey. *J. RAeS*, Apr., 1957, pp. 281–283. Exact solution of the streamlines of the slow viscous motion inside a cylinder with partially moving walls.

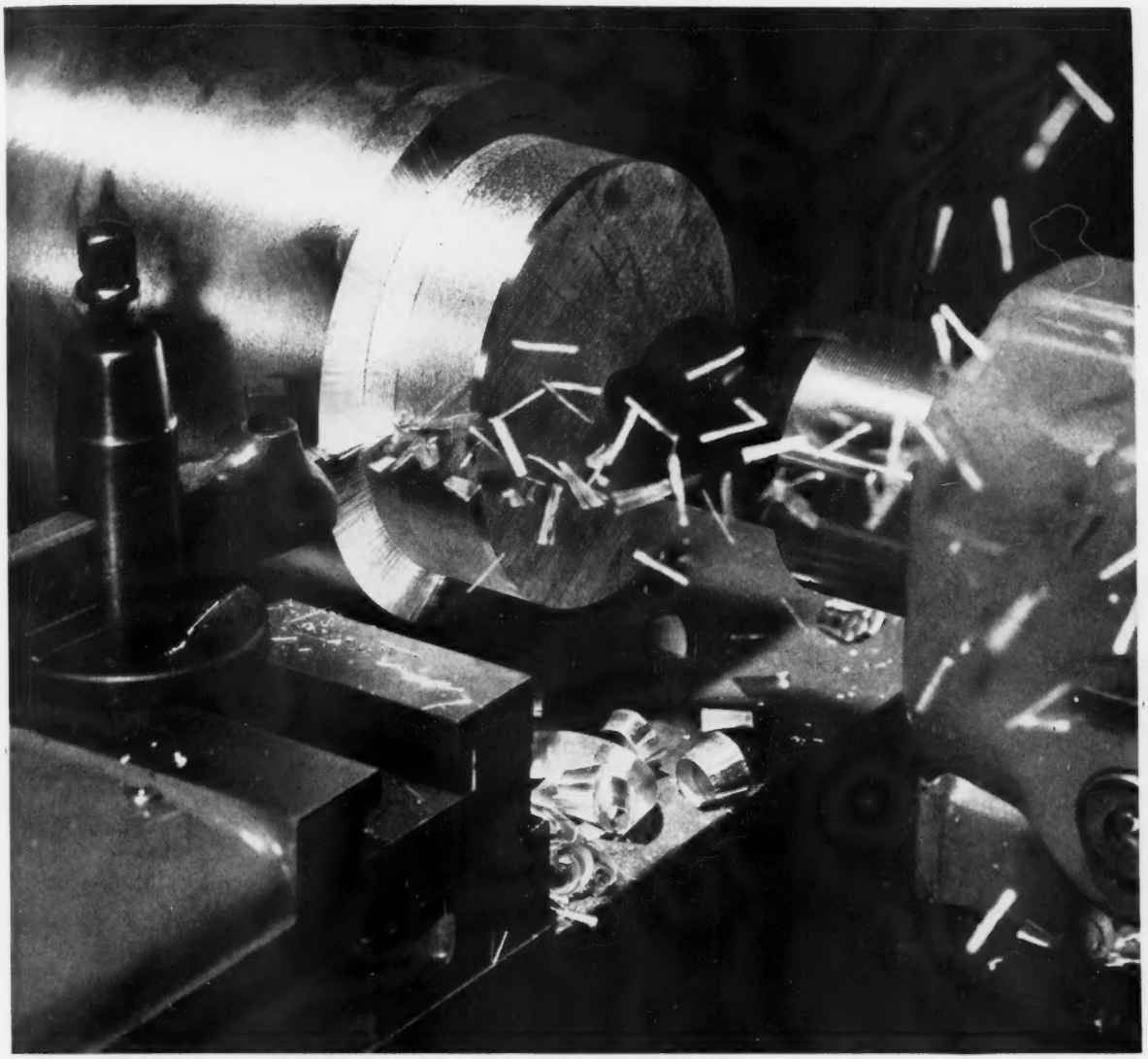
Theorie über die Gitterströmung beliebig geformter Flügelprofile mit grossen Wölbungs- und Dickenverhältnissen. H. Murai. *Tôhoku U., Rep. Inst. High Speed Mech.*, vol. 7, 1956, pp. 15–29. In German. Development of a theory for grid flow of arbitrarily shaped airfoil profiles with high camber and thickness ratios.

Wide-Angle Diffusers of High Performance and Diffuser Flow Mechanisms. S. J. Kline, C. A. Moore, and D. L. Cochran. *J. Aero. Sci.*, June, 1957, pp. 469, 470. Discussion of diffuser performance considering three basic parameters and four regimes of flow.

Flight Determination of Drag of Normal-Shock Nose Inlets with Various Cowling Profiles at Mach Numbers from 0.9 to 1.5. Appendix—Method Used to Determine the Drag and Mass-Flow Ratio for Normal-Shock Nose Inlets. R. I. Sears, C. F. Merlet, and L. W. Putland. *U.S., NACA Rep. 1281*, 1956. 19 pp. Supt. of Doc., Wash., $0.25. Test results on NACA 1-series, parabolic, and conic cowling profiles to investigate the external drag characteristics at an angle of attack of zero degrees.

Intensity, Scale, and Spectra of Turbulence in Mixing Region of Free Subsonic Jet. Appendix A, B—Analysis of Turbulence Spectra and Autocorrelograms. James C. Laurence. *U.S., NACA Rep. 1292*, 1956. 27 pp. 24 refs. Supt. of Doc., Wash., $0.30. Hot-wire anemometer measurements to obtain a scale, from a

(*Continued on page 133*)



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ACOUSTICS, SOUND, & NOISE

A COMPILATION OF TURBOJET NOISE DATA. Norman Doelling and D. M. A. Mercer. USAF WADC TR 54-401, July, 1956. 126 pp. Data obtained from measurements on conventional engines without jet-stream modifiers, in engine test facilities, and under static open-field conditions. About 100 measurements on 20 types and models of turbojets are included, of which 4 types are English and 16 American. For both open-field and test-facility measurements, total acoustic power and the distribution of power in octave bands of frequency are calculated and tabulated. In the case of open-field data, directivity information is presented in plots of sound-pressure level as a function of angle. Each acoustic measurement is accompanied by the engine-operating conditions existing at the time of the test and by a concise history noting data sources, the type of measurements, and the method used to calculate acoustic power.

AERODYNAMICS

Aerothermodynamics

STUDY OF STAGNATION TEMPERATURE AND PRESSURE IN A FREE-MOLECULAR FLOW REGIME, BY MEANS OF THE REVOLVING ARM METHOD. F. M. Devienne. Lab. Méditerranéen de Rech. Thermodynamiques TR (AFOSR TR 57-32) [AD 126495], Mar., 1957. 102 pp. Theoretical and experimental investigation including presentation of the stagnation-pressure theory and that concerning the rise in temperature of a plate moving perpendicular to its velocity; results of stagnation-pressure measurements, taken by means of a special type of ionization gage, up to speeds a little above 150 m./sec.; data on temperature rise and measurements of the ratios of the common value of the accomodation coefficient to apparent total emissivity and to total emissivity, for plates of different kinds in different gases up to speeds slightly above 300 m./sec.; and description of a new series of measurements taken up to speeds definitely above 300 m./sec.

TEMPERATURE ATTEINTE PAR UN ENGIN SE DEPLACANT DANS LA HAUTE ATMOSPHERE. Marcel Devienne. Fusées, Mar., 1957, pp. 43-47. In French. Evaluation of the equilibrium temperature of a missile moving at very high speed in a sufficiently rarefied atmosphere for the flow rate in the vicinity of the moving body to be the free molecular rate or the transition rate. These regimes take place according to the size and shape of the missile at minimum altitudes between 80 and 120 km. Experimental results obtained on models mounted on a support rotating with high speed in a very rarefied atmosphere can be used to calculate approximately the equilibrium temperatures for bodies having the shape of a plate or a sphere. These calculations help to demonstrate that the temperature of an artificial satellite reentering the atmosphere is rising rapidly.

EXPERIMENTAL STUDY OF THE VELOCITY AND TEMPERATURE DISTRIBUTION IN A HIGH-VELOCITY VORTEX-TYPE FLOW. J. P. Hartnett and E. R. G. Eckert. (Heat Transfer & Fluid Mech. Inst., Stanford, June 21-23, 1956.) Trans. ASME, May, 1957, pp. 751-758. Tests using a vortex tube to obtain a detailed knowledge of the temperature and flow fields in a vortex-type flow. Study is restricted to a vortex which is generated at the nozzle cross section and proceeds in one main direction down the tube, to be discharged through the exit at the far end of the tube. Other exit configurations are investigated to determine the influence of cone-value-exit geometry on the flow field.

AERODYNAMIC HEATING AND HEAT TRANSFER PHENOMENA AT MACH NUMBERS 3 TO 4. K. G. Anderson, H. B. Merrell, and J. M. Durben. USAF WADC TR 5840 (OTS PB 121243), Dec., 1951 (May, 1956). 106 pp. 28 refs. Experimental investigation to determine heat-transfer coefficients and recovery factors for heated bodies of revolution at Mach Numbers 2.98 and 3.67 and over a range of Reynolds Numbers from 0.16×10^6 to 1.0×10^6 per inch of characteristic length. Heat-

transfer results agree reasonably well with theory for a flat plate in compressible flow, as do the measured recovery factors with NACA flat-plate measurements. The transition regions for both phenomena are well defined for the existing test conditions. Treatment includes interferometer measurements of the temperature distribution in a boundary layer.

UPPER BOUNDS AND CONSERVATIVE ESTIMATES FOR AERODYNAMIC HEATING AT GREAT ALTITUDES. J. F. Vandrey. (ARS Fall Meeting, Buffalo, Sept. 24--26, 1956.) Jet Propulsion, May, 1957, pp. 522-526. Development of a simple calculation procedure based on energy considerations, which assumes the most unfavorable flow conditions. In nonmarginal cases, such as the launching vehicle for an artificial satellite, these upper bounds result in skin-temperatures low enough to serve as a guide for practical design purposes.

A THEORETICAL STUDY OF THE EFFECT OF UPSTREAM TRANSPIRATION COOLING ON THE HEAT-TRANSFER AND SKIN-FRICTION CHARACTERISTICS OF A COMPRESSIBLE, LAMINAR BOUNDARY LAYER. Appendix A - MATHEMATICAL DETAILS OF THE ANALYSIS. M. W. Rubesin and Mamoru Inouye. US, NACA TN 3969, May, 1957. 41 pp. Analysis concerning a solid flat plate preceded by a transpiration-cooled porous section. Treatment is restricted to a Prandtl Number of unity and linear variation of viscosity with temperature. Results indicate that the local skin friction has, in the region of transpiration cooling, a low value which increases until it approaches asymptotically the value for a completely nonporous surface; that, when the total coolant-flow rate is kept constant and the porous length is varied, the average skin friction on a partially porous plate is slightly lower than that on a fully porous plate; and that the local heat transfer behaves similarly to local skin friction.

Boundary Layer

BOUNDARY LAYER ALONG ANNULAR WALLS IN A SWIRLING FLOW. Hsuan Yeh. Johns Hopkins U. Mech. Eng. Dept. (AFOSR TN 57-105) [AD 120455], Apr., 1957. 41 pp. Theoretical and experimental investigation of swirling flow to develop equations for incompressible boundary layers along concave and convex stationary annular walls. It is shown that the integral momentum equation describing this type of boundary layer contains three correction terms to the conventional equation. The combined influence of these corrections appears to promote the growth of the boundary layer next to concave walls. Other differences between the boundary layers with swirl and those without swirl are also discussed. Measurements of turbulence intensities appear to confirm the interpretations reached.

LAMINAR BOUNDARY LAYER ON A SPINNING CIRCULAR CONE IN SUPERSONIC FLOW AT A SMALL ANGLE OF ATTACK. II. Martin Fiebig. Cornell U. Grad. Sch. Aero. Eng. Rep. (AFOSR TN 57-68) [AD 120410], Feb., 1957. 14 pp. Calculation of two lengths, characterizing the mass-flow defects, and determination of the displacement surface, starting from previously derived results for a similar spinning cone. Additional forces due to the asymmetry of the displacement surface are calculated by means of slender-body theory.

ON TRANSITION EXPERIMENTS AT MODERATE SUPERSONIC SPEEDS. M. V. Morkovin. J. Aero. Sci., July, 1957, pp. 480-486. 39 refs. OSR-ONR-supported hot-wire anemometer tests of transition over a flat plate at Mach Number 1.76. The nature and measurements of free-stream disturbances at supersonic speeds are analyzed. Experimental results are interpreted in the light of present overall information on transition at supersonic speeds.

REMARKS ON THE EQUILIBRIUM TURBULENT BOUNDARY LAYER. Donald Coles. J. Aero. Sci., July, 1957, pp. 495-506. 11 refs. Derivation of a method for computing the pressure distribution which corresponds to a given equilibrium flow. The hypothesis upon which the method is based is verified by experimental data for several equilibrium turbulent flows, and it is interpreted physically from a kinematic point of view. Two hypothetical limiting cases of equilibrium flow are described: at one extreme is the boundary layer in a sink flow, with a completely logarithmic mean-velocity profile outside the sublayer; at the other extreme is a continuously separating boundary layer in a dimensionless pressure gradient, approximately twice that for the corresponding laminar flow. Typical shearing-stress profiles are computed for several equilibrium turbulent flows, including the two limiting cases.

Fluid Mechanics & Aerodynamic Theory

ASYMPTOTIC BEHAVIOR AND UNIQUENESS OF PLANE SUBSONIC FLOWS. R. Finn and D. Gilbarg. Commun. on Pure & Appl. Math., Feb., 1957, pp. 23-63. 30 refs. ONR-sponsored establishment of asymptotic properties of subsonic flows defined in a neighborhood of infinity, using a method suitable for both nonuniformly and uniformly elliptic subsonic flows; and application of these results to the derivation of the force and moment formulas of gas dynamics, to the proof of uniqueness of subsonic flows past a profile, and to the determination of the complete expansion of a subsonic flow at infinity. The asymptotic properties of solutions of the flow equation appear as a special case of more general results concerning nonlinear elliptic equations. The proof exploits the Hölder continuity of the velocity vector at infinity. A theorem on removable singularities establishes that, in addition to being uniform and subsonic at infinity with the velocity having a specific asymptotic behavior, the flow must have further regularity properties which are expressed in the asymptotic formula for velocity.

UNA CARATTERISTICA DEI MOTI STABILI DI FLUIDI REALI. Carlo Riparbelli. L'Aerotecnica (Rome), Feb., 1957, pp. 13-23. 20 refs. In Italian. Definition of a principle of maximum power in which the stable distribution of velocities under

given forces or head pressures is the one for which the power available is a maximum. This last term is the difference between power introduced and power dissipated. The principal of maximum power in steady flow is formally reduced to Hamilton's principle by integrating the power terms over an arbitrary time interval. It is shown that this is true also if oscillations are present, provided the integration is extended to an integral number of periods.

RADIAL DISTRIBUTION FUNCTION OF FLUIDS. I. Kazuo Hiroike. J. Phys. Soc. Japan, Apr., 1957, pp. 326-334. 14 refs. Analysis of several approximate radial distribution functions of fluids to determine whether or not the free energy can be derived in a consistent way. It is shown that the original form of Green's linear theory is the only one that satisfies the desired thermodynamic relation for the pressure and the internal energy, and that this theory can be further improved without breaking that relation.

EFFECT OF BLUNTNESS ON TRANSITION FOR A CONE AND A HOLLOW CYLINDER AT MACH 3.1. Appendix A, B - DERIVATION OF ADJUSTED CONE BLUNTNESS REYNOLDS NUMBER. P. F. Brinich and Norman Sands. US, NACA TN 3979, May, 1957. 42 pp. 10 refs. Experimental results for a 10^{o} included-angle cone and a hollow cylinder. Both favorable and adverse effects of bluntness are found which depend on both the shape and size of bluntness used. The largest round bluntness displaces transition downstream by a factor of 3 on the cylinder and 1.3 on the cone. Large sharp-cornered flat bluntnesses displace transition upstream. It is believed that transition delay may be further influenced by such factors as pressure gradient over the nose section, which are favorable for the cylinder and unfavorable for the cone. Below a bluntness Reynolds Number of 20,000 to 50,000, both flat and round bluntnesses have the same delaying action on transition.

SUPERSONIC FLOW PAST SLENDER BODIES OF ARBITRARY SHAPE (PRACTICAL NUMERICAL METHODS FOR ELECTRONIC COMPUTERS). Robert Sauer. USAF OSR TN 1 (TN 57-162) [AD 126454], 1957. 15 pp. Derivation of the general theory based on the von Kármán-Moore-Tsien method for a slender body of arbitrary shape with a rectangular axis. In the generalized theory higher singularities (multipoles) are introduced and the solution is represented by Fourier series, the coefficients being sums of Legendre functions of the second kind. Considering only the first terms of Legendre functions, conical flow fields are obtained. As an example, the flow past a delta wing with elliptic cross section is discussed. The flow past a slender body is approximated by superposition of conical flow fields along the axis. This results in a practical numerical method for calculating the flow around slender bodies by a system of algebraic linear equations.

EXPANSIONS AT SMALL REYNOLDS NUMBERS FOR THE FLOW PAST A SPHERE AND A CIRCULAR CYLINDER. Ian Proudman and J. R. A. Pearson. J. Fluid Mech., May, 1957, pp. 237-262. 12 refs. Analysis to obtain higher approximations to the flow past a sphere and cylinder than represented by the solutions of Stokes and Oseen. Since the perturbation theory arising from the consideration of small non-zero Reynolds Numbers is a singular one, the problem is largely that of devising means for taking this singularity into account when expanding the solution for Reynolds Numbers. Separate, locally valid expansions of the stream function are developed for the regions close to, and far from, the obstacle. Substitution of these expressions in the Navier-Stokes equation then yields a set of differential equations. Since the Stokes and Oseen expansions are both derived from the same exact solutions, this leads to a matching of expansions, and it becomes possible to derive alternately successive terms in each expansion.

ON THE NON-EXISTENCE OF CONTINUOUS TRANSONIC FLOWS PAST PROFILES. II. C. S. Morawetz. Commun. on Pure & Appl. Math., Feb., 1957, pp. 107-131. OOR-sponsored extension of the proof that the transonic perturbation problem for the variation of a profile is incorrectly set, to the nonlinear problem involving the actual differences of the two velocity fields. It is shown that there are no solutions to the nonlinear boundary-value problem if the velocity and acceleration differences are bounded in a specific and natural way; this includes the result that there are no solutions to the perturbation problem.

ON THE TRANSONIC FLOW OF A COMPRESSIBLE FLUID PAST AN AXISYMMETRIC SLENDER BODY AT ZERO INCIDENCE. Ken-ichi Kusukawa. J. Phys. Soc. Japan, Apr., 1957, pp. 401-410. Theoretical investigation with results indicating that, by considering the von Kármán transonic similarity solution and the Oswatisch-Berndt general similarity rule of axisymmetric transonic flow, the surface-pressure coefficient of an axisymmetric flow can easily be obtained, provided the surface-pressure coefficient of a two-dimensional flow can be found. As an example, the pressure distribution on the surface of a parabaloid of revolution of finite length is determined at Mach Number 1.

DIFFERENZENVERFAHREN ZUM BERECHNEN VON TEMPERATUR-AUSGLEICHSVORGÄNGEN BEI EINDIMENSIONALER WÄRMESTRÖMUNG IN EINFACHEN UND ZUSAMMENGESETZTEN KÖRPERN. Herbert Schuh. VDI-Forschungsheft 459, 1957. 43 pp. 20 refs. In German. Development of a finite difference method for calculating transient temperature distributions due to one-dimensional heat flow in simple and composite bodies. The use of high-speed electronic computers for solving finite difference equations is discussed, and examples to demonstrate the applicability of the method are presented.

THE HYPERSONIC VISCOUS EFFECT ON A FLAT PLATE WITH FINITE LEADING EDGE. A. G. Hammitt. Princeton U. Dept. Aero. Eng., Rep. 378 (WADC TN 57-105) [AD 118152], Mar., 1957.

24 pp. 25 refs. Theoretical investigation to account for the Reynolds Number dependence on the pressure distribution along the forward parts of flat plates. Experimental data demonstrating this dependence is presented for both air and helium over a wide range of leading-edge Reynolds Numbers. A calculation method is developed which takes into account the finite leading-edge thickness of the body and the detached shock wave.

THE MOTION OF A SHOCK WAVE IN A CHANNEL, WITH APPLICATIONS TO CYLINDRICAL AND SPHERICAL SHOCK WAVES. R. F. Chisnell. J. Fluid Mech., May, 1957, pp. 286-298. Derivation of a first order relationship between changes in area and shock strength for the case of a shock moving through a small area change in a channel. By integrating this relationship, the area of the channel is obtained as a function of the shock strength in closed form. This result is interpreted as providing the average strength of a shock at a given time as it moves along a channel of arbitrary shape. By suitable choices of the shape of the channel, descriptions of converging cylindrical and spherical shocks are obtained.

AN ANALYSIS OF THE INTERACTION OF SHOCK WAVES WITH UNSEPARATED TURBULENT BOUNDARY LAYERS. A. G. Hammitt. Princeton U., Dept. Aero. Eng., Rep. 371 (AFOSR TN 57-108) [AD 120460], Feb., 1957. 24 pp. 13 refs. Analysis of the behavior of turbulent boundary layers through rapid pressure rises using a modified shock wave theory based on average boundary layer parameters. This method may be applied to shock wave boundary layer interactions at pressure ratios insufficient to cause separation. The results show that the properties of a boundary layer behind a discontinuous pressure rise may be considerably different than the ones measured in mild pressure gradients.

INTERFEROMETRIC TEST FOR N-WAVE FLOW. D. H. Steininger and F. D. Bennett. J. Fluid Mech., May, 1957, pp. 209-236. 18 refs. Derivation of an analytical expression for the fringe shift in the N-wave, from the improved linearized theory for a slender supersonic projectile. From this expression an approximate mapping function is found which gives a simple test for N-wave flow. The validity of the fringe shift expression is quantitatively confirmed by measuring an interferogram of the flow around a sphere. N-wave flow is shown to exist around a small sphere for r greater than about 70 diams. Measurements of the shock waves from a sphere and a cone-cylinder show that the shocks assume their asymptotic positions for $r > 14$ diams. for the sphere, and $r > 7$ diams. for the cone-cylinder.

REFLEXION EBENER DRUCKWELLEN AN EINER FESTEN WAND. C. Heinz. ZAMM, Jan.-Feb., 1957, pp. 63-73. In German. Analysis of the reflection from a solid wall of a plane pressure wave consisting of a shock wave and a subsequent expansion wave. The two-dimensional velocity potential of the problem satisfies the Darboux equation, and the solutions of this equation as given by Hadamard are used in reiterated form to determine both the shock wave and the velocity field between wave and wall. Includes discussion of the inverse problem where the pressure on the wall is given and the incident wave has to be found. The reflection of several waves is computed as an example.

DAS ZEITLICHE ABKLINGEN DER STÖRUNGEN NACH DER UMLENKUNG EINES FORTSCHREITENDEN VERDICHTUNGSSTOSSES DURCH EINEN SCHWACHEN KNICK IN EINEM KANAL KONSTANTEN QUERSCHNITTS. E. A. Müller. ZFW, Apr., 1957, pp. 114-120. 11 refs. In German. Study of the unsteady two-dimensional problem of shock waves of arbitrary strength through linearization of the basic equations of gas dynamics and superposition of fundamental "conic" solutions. An analytic expression for the "adjustment" time is derived, and the results are discussed in terms of the Mach Number $1<M<5$.

OPTIMUM NOSE SHAPES FOR MISSILES IN THE SUPERAERODYNAMIC REGION. W. J. Carter. J. Aero. Sci., July, 1957, pp. 527-532. Analysis using the mechanics of the kinetic theory of gases to describe the drag force on the nose of a missile moving in the superaerodynamic region of the atmosphere. Three separate cases are considered - ideal specular reflection, specular-type reflection from a slightly rough surface, and surface absorption followed by random emission of the stribing molecules. Using the calculus of variations, a differential equation is obtained and solved by a numerical procedure for the nose shape which minimizes the drag force in each of the three cases. The drag coefficients for the optimum nose shapes are likewise determined and these are compared with the drag coefficients given by other nose shapes.

THE INHOMOGENEITY OF GRID TURBULENCE. H. L. Grant and I. C. T. Nisbet. J. Fluid Mech., May, 1957, pp. 263-272. Investigation of turbulent motion in the wake of square mesh grid of bars. The measurements show that there are considerable departures from homogeneity over surfaces normal to the mean stream. This inhomogeneity is believed to be the cause of the discrepancies between various sets of measurements of energy decay in the initial period.

THE INFLUENCE OF FINITE OBSERVATION INTERVALS ON THE MEASUREMENT OF TURBULENT DIFFUSION PARAMETERS. Y. Ogura. J. Meteorology, Apr., 1957, pp. 176-181. 15 refs. OSR-ONR-OOR-sponsored investigation of the errors involved in confirming measurements to a finite observation interval. The correlation functions obtained from truncated samples are expressed in terms of the sampling length and the correlation functions of the basic stationary random variables. The application of the results to diffusion phenomena in a turbulent flow is discussed. It is also shown that the turbulent level is important in determining the relationship between the Eulerian and Lagrangian time intervals of observation.

Internal Flow

A METHOD OF CASCADE DESIGN FOR TWO-DIMENSIONAL INCOMPRESSIBLE FLOW. S. Rosenblat and L. C. Woods. Australia, Aero. Res. Comm. Rep. ACA-58, Mar., 1956. 30 pp. Development of a technique in which the velocity distribution need only be specified numerically as a function of chord distance, as is the case in practical design problems. The method is based on one obtained by Woods for the design of a single airfoil, and serves as an alternative procedure to that devised by Lighthill, in which the velocity distribution on the airfoil surface must be an analytic function. Includes description of the design of an actual cascade in which the velocity distribution is specified on the upper and lower surfaces of an airfoil, a given range of inlet and outlet flow angles is required, and the gap-chord ratio is prescribed.

PROBLEMS ENCOUNTERED IN THE TRANSLATION OF COMPRESSOR PERFORMANCE FROM ONE GAS TO ANOTHER. Appendix - EQUATIONS AND METHODS NECESSARY FOR TRANSLATION OF COMPRESSOR PERFORMANCE. M. J. Hartmann and W. W. Wilcox. (ASME Semi-Annual Meeting, Cleveland, June 17-21, 1956, Paper 56--SA-61.) Trans. ASME, May, 1957, pp. 887-897; Discussion, p. 897. Presentation of the experimental methods used in testing compressors in a closed loop with Freon-12 as the test medium. The problems of indicating the purity of the test gas and maintaining the desired operating conditions suggest some of the problems that compressor test stands using special test media may encounter.

CHARTS FOR THE ANALYSIS OF FLOW IN A WHIRLING DUCT. R. A. Makofski. US, NACA TN 3950, May, 1957. 21 pp. Development of charts for determining the duct-exit Mach Number or the Mach Number at any point along the duct, for practical ranges of duct-inlet Mach Number, friction factor, ratio of ambient temperature to duct-flow total temperature, ratio of duct-tip radius to duct hydraulic diameter, and heat conductivity through the duct wall and surrounding material. The method of using the charts is illustrated by a simple example.

CRITERIA FOR VALIDITY OF LUMPED-PARAMETER REPRESENTATION OF DUCTING AIR-FLOW CHARACTERISTICS. Appendix I - VALVE AIR-FLOW CHARACTERISTICS. Appendix II - RAMJET-ENGINE AIR-FLOW CHARACTERISTICS. T. R. Stalzer and G. J. Fiedler. (ASME-ISA Conf., New York, Sept. 17-21, 1956, Paper 56--IRD 20.) Trans. ASME, May, 1957, pp. 833-839. 11 refs. Derivation of differential equations for the distributed-parameter and the lumped-parameter representations. Using applicable linearized assumptions, transfer functions are obtained for each representation. The two transfer functions are compared by applying them to a practical valve-and-ducting system selected from a control problem, and a simple numerical criterion is developed to determine rapidly the conditions under which lumped representation is valid. Frequency-repsonse and time-response plots for the lumped and distributed elements are included for purposes of comparison.

PERFORMANCE OF A MACH 4 AXIALLY SYMMETRIC NOZZLE DESIGNED TO OPERATE AT 40 MICRONS HG. IN THE UTIA LOW DENSITY WIND TUNNEL. Appendix I - DESIGN OF MACH 4 AXISYMMETRIC NOZZLE TO OPERATE AT A STATIC PRESSURE OF 40 MICRONS, HG. Appendix II - CALCULATION OF THE LAMINAR BOUNDARY LAYER GROWTH ON THE WALLS OF THE MACH 4 AXISYMMETRIC NOZZLE BY A METHOD DUE TO THWAITES, ROTT, CRABTREE, ET AL. A. K. Sreekanth. UTIA TN 10 (AFOSR TN 57-94) [AD 120443], Sept., 1956. 80 pp. Theoretical and experimental results indicate that the anticipated Mach Number distribution is obtained at the design operating conditions. The data from a series of runs at pressures from 29 to 46 microns of mercury indicate that the boundary-layer displacement thickness varies inversely as the square root of the operating static pressure. The boundary-layer thickness at the nozzle throat, as determined from mass-flow measurements, agrees well with the calculated value based on the assumption of zero rate of boundary layer growth at the throat. Additional investigations are made on the effect of the stagnation temperature and the pressure in the open-jet test chamber on the flow.

Wings & Airfoils

THE CALCULATION OF THE PRESSURE DISTRIBUTION ON THICK WINGS OF SMALL ASPECT RATIO AT ZERO LIFT IN SUBSONIC FLOW. Appendix - APPROXIMATION OF CERTAIN INTEGRALS BY FINITE SUMS. J. Weber. Gt. Brit., ARC R&M 2993, 1957. 45 pp. 19 refs. BIS, New York, $2.34. Extension of Küchemann and Weber's method of expressing the velocity increment over airfoils directly in terms of the section ordinates, to cover straight and swept wings of finite aspect ratio. The wings considered are untapered in plan form but may be tapered in thickness, and the section may be of any shape. The relations between linear, slender-body, and linearized slender-body theory are discussed and, for the special case of ellipsoids, the results obtained from the various methods are compared with the exact solution.

THE UNSTEADY MOTION OF A THIN AEROFOIL IN AN INCOMPRESSIBLE FLUID. D. S. Jones. Commun. on Pure & Appl. Math., Feb., 1957, pp. 1-21. 11 refs. Solution by means of Mellin transforms of the mathematical problem resulting from the assumption that the airfoil may be approximated by a polynomial curve and that the boundary condition on the curve may be replaced by one on the chord. Formulas are obtained for the pressure distribution, drag, lift, and downwash, and those for the two last parameters are rewritten so as to be applicable when the polynomial approximation is not made. Reversed-flow theorems are given for deriving many aerodynamic forces, e. g., the moment, from the pressure distribution of the

reversed flow with a polynomial approximation. These quantities can then be deduced from the above theory.

DRUCKVERTEILUNGEN BEKANNTER PROFILTYPEN BEI INKOMPRESSIBLER STRÖMUNG. G. Jungclaus. ZFW, Apr., 1957, pp. 106-114. In German. Analytical solution of the integrals, for several special cases, which appear in the velocity-distribution formula resulting from the calculation of incompressible flow around airfoil sections by means of Riegel's approximate method, and which are evaluated by mechanical quadratures. Finite expressions are given for the distributions of velocity, circulation, and pressure at the airfoil. Some examples are calculated and their results are plotted and compared with those of other methods, some of which are exact.

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MATERIALS

EVALUATION OF POROUS MATERIALS FOR BOUNDARY-LAYER CONTROL. D. E. Debeau. USAF WADC TR 56-486 [AD 110582] (OTS, PB

121851, $4.00), Nov., 1956. 154 pp. Review of various designers' criteria for comparing a number of permeable sheet materials. Sintered metal powders, special woven and sintered wire materials, a compressed glass-fiber product, woven wire cloths, and perforated metal sheets are evaluated and compared for the following properties: average permeability, uniformity of permeability, resistance to clogging and corrosion, mechanical properties including room-temperature tensile strength, modulus of elasticity, Poisson's ratio, and minimum bend radius. An evaluation of economic factors is carried out on those permeable sheet materials which attain most nearly the physical and mechanical properties desired by the aircraft designers.

Metals & Alloys

THE EFFECT OF STATIC MEAN STRESS ON THE DAMPING PROPERTIES OF MATERIALS. Appendix A - SOURCES OF ENERGY DISSIPATION DURING THE BENDING VIBRATION DECAY TEST. Appendix B - CORRELATION OF BENDING VIBRATION DECAY AND ROTATING BEAM DAMPING DATA. N. L. Person and B. J. Lazan. USAF WADC TR 55-497 [AD 97123], July, 1956. 28 pp. 14 refs. Experimental investigation using new bending vibration equipment developed for the purpose of determining the effect of static mean stress on the damping associated with a given alternating stress. Tests are performed on SAE 1020 steel, 2024-T aluminum, J-1 magnesium, annealed RC-55 titanium, S-816 alloy, glass laminate plastic, and 403 stainless steel. In all cases the maximum stress on the test specimens is kept below the cyclic-stress sensitivity so that damping may remain unchanged by stress history. Results show 403 steel to be the only material displaying a significant change in the damping due to superimposed static mean stress.

ON THE COMPUTATION OF RELAXATION STRESSES IN METALS. L. M. Shestopalov. Soviet Physics - Tech. Physics, No. 5, 1957, pp. 998-1,009. Translation. Theoretical and experimental investigation of the phenomena. Analysis considers a real crystal which differs from the ideal crystal lattice by the presence of microscopic distortions such as vacant spaces, included atoms, and group distortions resulting from the presence of the former. It is shown that stress relaxation in metals is evidence of internal rearrangement of the lattice of a real crystal which is in a nonequilibrium condition; the mobility of the atoms in such a system is reduced with an increase of binding energy, and is increased with an increase in temperature.

FATIGUE, CREEP, AND RUPTURE PROPERTIES OF HEAT RESISTANT MATERIALS. F. H. Vitovec and B. J. Lazan. USAF WADC TR 56-181 [AD 97240], Aug., 1956. 196 pp. 12 refs. Test results for the following alloys: Stellite 31, S-816, 6.3% Mo-Waspalloy, 7% Mo-Waspalloy, M-252, Inconel X-550, Timken 16-25-6, Crucible 422, Lapelloy, and Stainless type 403. Tests are performed under axial stress on unnotched specimens and specimens having theoretical stress concentration factors of 2.4 and 3.4. The data are presented as S-N curves and stress-range diagrams to show the effect, on the fatigue and creep properties, of specimen notch, temperature, ratio of alternating-to-mean stress, and stress magnitude. The role of both creep and fatigue as design factors and the relation of notch sensitivity to loading conditions are discussed with particular reference to temperature and ratio of alternating-to-mean stress.

Metals & Alloys, Nonferrous

NON-LINEAR ELASTICITY IN ALUMINIUM ALLOYS. Appendix I - CALCULATION OF CONVENTIONAL STRESS-STRAIN CURVE AND TANGENT MODULUS FOR CONSTANT TRUE "E". Appendix II - THE THEORY OF ELASTIC MODULUS VARIATION. A. B. Watts. Aero. Quart., May, 1957, pp. 103-122. Tests on round bar specimens of various strong aluminum alloys (unclad) in the fully heat-treated condition in both tensile and compressive loading, including tests on two aluminum alloys other than those of the normal zinc-bearing and copper-bearing types. The first of these latter alloys is a simple, fully heat-treated, binary alloy of 4% copper, similar in behavior to D. T. D. 364; the second is a 5% alloy (N. S. 6-1/2H). An additional experiment is carried out to compare naturally and artificially aged D. T. D. 364.

MATHEMATICS

THE APPLICATION OF MATRIX METHODS TO COORDINATE TRANSFORMATIONS OCCURRING IN SYSTEMS STUDIES INVOLVING LARGE MOTIONS OF AIRCRAFT. B. F. Doolin. US, NACA TN 3968, May, 1957. 36 pp. Method for using matrix algebra to set up geometric aspects of problems for aircraft in motion. The geometry is formulated by fixing quantities whose relative motions are to be studied each in a coordinate system of its own. The various coordinate systems are related to each other by orthogonal transformations in matrix form, and the parameters defining the transformations are found in terms of the dynamical variables of the problem with the help of the transformation matrices. Application is made to several examples.

MISSILES

BOOST PHASE TRAJECTORY ANALYSIS TECHNIQUES. C. D. West. Jet Propulsion, May, 1957, pp. 527-533. NavBuAer-supported analysis using four numerical approaches to the solution of the equations for a cruciform, uncontrolled missile booster. The first, exact method, yields results which can be carried to any desired accuracy. The semi-exact method assumes that deviations from the flight path are small and oscillatory, and the accuracy is as good as the exact method. The third method, the linear speed-time history, assumes a constant acceleration from launch to the end of boost, and has an accuracy on the order of 2% for the terminal speed. The fourth, called the iterative solution for separation speed, yields an approximate value for the terminal speed with accuracy on the order of 2 to 4%.

METODO FOTOGRAFICO PER LA DETERMINAZIONE DELLA RESISTENZA AERODINAMICA DI MISSILI IN VOLO. C. E. Cremona. Astronautica Acta, Fasc. 1, 1957, pp. 52-66. 13 refs. In Italian, with summaries in English, German, and French. Method for determining the aerodynamic drag of a flying missile based upon the comparison of some parameters of the trajectory that can be calculated by optical and optical-electronic methods, and the corresponding parameters belonging to families of missile trajectories that have been determined theoretically. Four methods for obtaining trajectories are described.

GEOMETRICAL STABILIZATION BASED ON SERVODRIVEN GIMBALS AND INTEGRATING GYRO UNITS. C. S. Draper and R. B. Woodbury. (NATO AGARD Symposium, Venice, Sept. 24-28, 1956.) MIT Paper, Dec., 1956. 35 pp. 19 refs. Analysis of the mechanical features and operating characteristics of orientational reference systems, capable of changing the orientation of the indicated geometrical reference in response to command inputs, that are based on single-degree-of-freedom integrating gyro units supported by servodriven gimbals. From information summarized in a functional diagram for a typical gimbal stabilization system, the performance equation for motion about a single gimbal axis is set up in a form that may be adapted to describe the behavior of the complete system when drives for all three axes are in simultaneous operation.

MISSILE GUIDANCE TECHNIQUES AND GUIDED MISSILE WEAPONS SYSTEM CONSIDERATIONS. W. C. Hodgson and J. C. Ryon. Fusées, Mar., 1957, pp. 53-63. Description of such missile guidance techniques as homing guidance (passive, semiactive, and active), command guidance, and beamrider guidance. Hyperbolic navigation and the use of inertial, terrestrial, and celestial references for guidance are discussed. In order to illustrate the basic tactical applications of a guidance technique, the semiactive homing method is described as conventionally applied to these four categories: surface-to-air, air-to-air, air-to-surface, and surface-to-surface missiles. A generalized missile weapons system is also described, including the target, target detection and tracking, target designation and computation, data processing and transmission, target acquisition and tracking, launcher and missile preparation, missile guidance, and fusing.

NAVIGATION

Electronic Aids

RADAR VIDEO INTEGRATOR STUDY; INTERNAL RESEARCH PROJECT 81-011. Appendix I - AMPLITUDE DISTRIBUTION OF INTEGRATED NOISE. Appendix II - APPROXIMATE AMPLITUDE DISTRIBUTION OF INTEGRATED NOISE GOOD FOR SMALL EXCEEDANCE PROBABILITIES. Appendix III - THEORETICAL MEAN AND VARIANCE OF INTEGRATED VIDEO. R. W. Hendrick. Cornell Aero. Lab. Rep. CAL-78, Jan., 1957. 49 pp. 14 refs. Development of an optimum signal integrator and presentation of methods to evaluate the quality of its operation and to predict the operational characteristics of future systems. The integrator consists of a cathode-ray tube phosphor storage with photomultiplier readout. The reversal returns from a target are weighted according to their expected value, which is the optimum weighting for detecting targets. Measured amplitude distribution functions of integrated video are combined with a theoretical determination of the distribution of integrated noise and compared with theoretically derived distributions. Results indicate that the radar equipment utilizing video integration should operate satisfactorily at ranges 1.5 to 2 times that possible using raw video.

ON THE FREQUENCY SPECTRUM GENERATED BY A MANEUVERING AIRCRAFT. A. P. Brogle. J. Aero. Sci., July, 1957, pp. 487-494. Derivation of an upper amplitude limit for the frequency spectrum of an aircraft in motion. The existence of a bound on the absolute value of acceleration is the underlying phenomenon determining the limit on the transformed position motion. In obtaining this bound, only periodic motions of the aircraft are considered, and the only aircraft characteristic taken into account is maximum acceleration. It is shown that the derived maximum may be applied to the determination of the bandwidth characteristics for a communication-control fire direction or interception system. A simple relationship is found to exist between the value of the amplitude limit at any frequency and the maximum error in position, without regard to time delay and noise, which occurs in a communication-control system of specified bandwidth.

NUCLEAR ENERGY

INVESTIGATION INTO THE NATURE OF SHORT RANGE NUCLEAR FORCES. K. G. Foelsch. GRC Rep. 12555 (AFOSR TN 57-145) [AD 126434], Mar. 15, 1957. 36 pp. Analysis to simplify the physical picture of a nucleus by assuming that electrons and positrons, the elementary particles, are the building material of the nucleon (proton and neutron). An experimental function of the distance is introduced with a linear coupling factor which is computed from the electrostatic charge of the elementary particle and its mass. By this function the character of the Coulomb Law in the nuclear field is substantially changed, thereby providing the possibility of obtaining electrostatic equilibrium between any number of electrons and positrons. This new idea is first applied to the dynamics of the mass point.

SITUATION PRESENTE DU PROBLEME DES FUSEES PROPULSEES AU MOYEN DE L'ENERGIE NUCLEAIRE. F. Winterberg. Fusées, Mar., 1957, pp. 9-22. In French. Discussion of the present state of problems presented by nuclear propulsion. Includes: analysis of nuclear techniques and rocket techniques; consideration of the rapidly-critical gas reactor as the rocket combustion chamber; critical range of a gas reactor; nuclear-combustion gases; equations of the rapidly-critical gas reaction; energy production ratio as function of the pressure and temperature; combus-

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MATERIALS

EVALUATION OF POROUS MATERIALS FOR BOUNDARY-LAYER CONTROL. D. E. Debeau. USAF WADC TR 56-486 [AD 110582] (OTS, PB

121851, $4.00), Nov., 1956. 154 pp. Review of various designers' criteria for comparing a number of permeable sheet materials. Sintered metal powders, special woven and sintered wire materials, a compressed glass-fiber product, woven wire cloths, and perforated metal sheets are evaluated and compared for the following properties: average permeability, uniformity of permeability, resistance to clogging and corrosion, mechanical properties including room-temperature tensile strength, modulus of elasticity, Poisson's ratio, and minimum bend radius. An evaluation of economic factors is carried out on those permeable sheet materials which attain most nearly the physical and mechanical properties desired by the aircraft designers.

Metals & Alloys

THE EFFECT OF STATIC MEAN STRESS ON THE DAMPING PROPERTIES OF MATERIALS. Appendix A - SOURCES OF ENERGY DISSIPATION DURING THE BENDING VIBRATION DECAY TEST. Appendix B - CORRELATION OF BENDING VIBRATION DECAY AND ROTATING BEAM DAMPING DATA. N. L. Person and B. J. Lazan. USAF WADC TR 55-497 [AD 97123], July, 1956. 28 pp. 14 refs. Experimental investigation using new bending vibration equipment developed for the purpose of determining the effect of static mean stress on the damping associated with a given alternating stress. Tests are performed on SAE 1020 steel, 2024-T aluminum, J-1 magnesium, annealed RC-55 titanium, S-816 alloy, glass laminate plastic, and 403 stainless steel. In all cases the maximum stress on the test specimens is kept below the cyclic-stress sensitivity so that damping may remain unchanged by stress history. Results show 403 steel to be the only material displaying a significant change in the damping due to superimposed static mean stress.

ON THE COMPUTATION OF RELAXATION STRESSES IN METALS. L. M. Shestopalov. Soviet Physics - Tech. Physics, No. 5, 1957, pp. 998-1,009. Translation. Theoretical and experimental investigation of the phenomena. Analysis considers a real crystal which differs from the ideal crystal lattice by the presence of microscopic distortions such as vacant spaces, included atoms, and group distortions resulting from the presence of the former. It is shown that stress relaxation in metals is evidence of internal rearrangement of the lattice of a real crystal which is in a nonequilibrium condition; the mobility of the atoms in such a system is reduced with an increase of binding energy, and is increased with an increase in temperature.

FATIGUE, CREEP, AND RUPTURE PROPERTIES OF HEAT RESISTANT MATERIALS. F. H. Vitovec and B. J. Lazan. USAF WADC TR 56-181 [AD 97240], Aug., 1956. 196 pp. 12 refs. Test results for the following alloys: Stellite 31, S-816, 6.3% Mo-Waspalloy, 7% Mo-Waspalloy, M-252, Inconel X-550, Timken 16-25-6, Crucible 422, Lapelloy, and Stainless type 403. Tests are performed under axial stress on unnotched specimens and specimens having theoretical stress concentration factors of 2.4 and 3.4. The data are presented as S-N curves and stress-range diagrams to show the effect, on the fatigue and creep properties, of specimen notch, temperature, ratio of alternating-to-mean stress, and stress magnitude. The role of both creep and fatigue as design factors and the relation of notch sensitivity to loading conditions are discussed with particular reference to temperature and ratio of alternating-to-mean stress.

Metals & Alloys, Nonferrous

NON-LINEAR ELASTICITY IN ALUMINIUM ALLOYS. Appendix I - CALCULATION OF CONVENTIONAL STRESS-STRAIN CURVE AND TANGENT MODULUS FOR CONSTANT TRUE "E". Appendix II - THE THEORY OF ELASTIC MODULUS VARIATION. A. B. Watts. Aero. Quart., May, 1957, pp. 103-122. Tests on round bar specimens of various strong aluminum alloys (unclad) in the fully heat-treated condition in both tensile and compressive loading, including tests on two aluminum alloys other than those of the normal zinc-bearing and copper-bearing types. The first of these latter alloys is a simple, fully heat-treated, binary alloy of 4% copper, similar in behavior to D.T.D.364; the second is a 5% alloy (N.S.6-1/2H). An additional experiment is carried out to compare naturally and artificially aged D.T.D.364.

MATHEMATICS

THE APPLICATION OF MATRIX METHODS TO COORDINATE TRANSFORMATIONS OCCURRING IN SYSTEMS STUDIES INVOLVING LARGE MOTIONS OF AIRCRAFT. B. F. Doolin. US, NACA TN 3968, May, 1957. 36 pp. Method for using matrix algebra to set up geometric aspects of problems for aircraft in motion. The geometry is formulated by fixing quantities whose relative motions are to be studied each in a coordinate system of its own. The various coordinate systems are related to each other by orthogonal transformations in matrix form, and the parameters defining the transformations are found in terms of the dynamical variables of the problem with the help of the transformation matrices. Application is made to several examples.

MISSILES

BOOST PHASE TRAJECTORY ANALYSIS TECHNIQUES. C. D. West. Jet Propulsion, May, 1957, pp. 527-533. NavBuAer-supported analysis using four numerical approaches to the solution of the equations for a cruciform, uncontrolled missile booster. The first, exact method, yields results which can be carried to any desired accuracy. The semi-exact method assumes that deviations from the flight path are small and oscillatory, and the accuracy is as good as the exact method. The third method, the linear speed-time history, assumes a constant acceleration from launch to the end of boost, and has an accuracy on the order of 2% for the terminal speed. The fourth, called the iterative solution for separation speed, yields an approximate value for the terminal speed with accuracy on the order of 2 to 4%.

METODO FOTOGRAFICO PER LA DETERMINAZIONE DELLA RESISTENZA AERODINAMICA DI MISSILI IN VOLO. C. E. Cremona. Astronautica Acta, Fasc. 1, 1957, pp. 52-66. 13 refs. In Italian, with summaries in English, German, and French. Method for determining the aerodynamic drag of a flying missile based upon the comparison of some parameters of the trajectory that can be calculated by optical and optical-electronic methods, and the corresponding parameters belonging to families of missile trajectories that have been determined theoretically. Four methods for obtaining trajectories are described.

GEOMETRICAL STABILIZATION BASED ON SERVODRIVEN GIMBALS AND INTEGRATING GYRO UNITS. C. S. Draper and R. B. Woodbury. (NATO AGARD Symposium, Venice, Sept. 24-28, 1956.) MIT Paper, Dec., 1956. 35 pp. 19 refs. Analysis of the mechanical features and operating characteristics of orientational reference systems, capable of changing the orientation of the indicated geometrical reference in response to command inputs, that are based on single-degree-of-freedom integrating gyro units supported by servodriven gimbals. From information summarized in a functional diagram for a typical gimbal stabilization system, the performance equation for motion about a single gimbal axis is set up in a form that may be adapted to describe the behavior of the complete system when drives for all three axes are in simultaneous operation.

MISSILE GUIDANCE TECHNIQUES AND GUIDED MISSILE WEAPONS SYSTEM CONSIDERATIONS. W. C. Hodgson and J. C. Ryon. Fusées, Mar., 1957, pp. 53-63. Description of such missile guidance techniques as homing guidance (passive, semiactive, and active), command guidance, and beamrider guidance. Hyperbolic navigation and the use of inertial, terrestrial, and celestial references for guidance are discussed. In order to illustrate the basic tactical applications of a guidance technique, the semiactive homing method is described as conventionally applied to these four categories: surface-to-air, air-to-air, air-to-surface, and surface-to-surface missiles. A generalized missile weapons system is also described, including the target, target detection and tracking, target designation and computation, data processing and transmission, target acquisition and tracking, launcher and missile preparation, missile guidance, and fusing.

NAVIGATION

Electronic Aids

RADAR VIDEO INTEGRATOR STUDY; INTERNAL RESEARCH PROJECT 81-011. Appendix I - AMPLITUDE DISTRIBUTION OF INTEGRATED NOISE. Appendix II - APPROXIMATE AMPLITUDE DISTRIBUTION OF INTEGRATED NOISE GOOD FOR SMALL EXCEEDANCE PROBABILITIES. Appendix III - THEORETICAL MEAN AND VARIANCE OF INTEGRATED VIDEO. R. W. Hendrick. Cornell Aero. Lab. Rep. CAL-78, Jan., 1957. 49 pp. 14 refs. Development of an optimum signal integrator and presentation of methods to evaluate the quality of its operation and to predict the operational characteristics of future systems. The integrator consists of a cathode-ray tube phosphor storage with photomultiplier readout. The reversal returns from a target are weighted according to their expected value, which is the optimum weighting for detecting targets. Measured amplitude distribution functions of integrated video are combined with a theoretical determination of the distribution of integrated noise and compared with theoretically derived distributions. Results indicate that the radar equipment utilizing video integration should operate satisfactorily at ranges 1.5 to 2 times that possible using raw video.

ON THE FREQUENCY SPECTRUM GENERATED BY A MANEUVERING AIRCRAFT. A. P. Brogle. J. Aero. Sci., July, 1957, pp. 487-494. Derivation of an upper amplitude limit for the frequency spectrum of an aircraft in motion. The existence of a bound on the absolute value of acceleration is the underlying phenomenon determining the limit on the transformed position motion. In obtaining this bound, only periodic motions of the aircraft are considered, and the only aircraft characteristic taken into account is maximum acceleration. It is shown that the derived maximum may be applied to the determination of the bandwidth characteristics for a communication-control fire direction or interception system. A simple relationship is found to exist between the value of the amplitude limit at any frequency and the maximum error in position, without regard to time delay and noise, which occurs in a communication-control system of specified bandwidth.

NUCLEAR ENERGY

INVESTIGATION INTO THE NATURE OF SHORT RANGE NUCLEAR FORCES. K. G. Foelsch. GRC Rep. 12555 (AFOSR TN 57-145) [AD 126434], Mar. 15, 1957. 36 pp. Analysis to simplify the physical picture of a nucleus by assuming that electrons and positrons, the elementary particles, are the building material of the nucleon (proton and neutron). An experimental function of the distance is introduced with a linear coupling factor which is computed from the electrostatic charge of the elementary particle and its mass. By this function the character of the Coulomb Law in the nuclear field is substantially changed, thereby providing the possibility of obtaining electrostatic equilibrium between any number of electrons and positrons. This new idea is first applied to the dynamics of the mass point.

SITUATION PRESENTE DU PROBLEME DES FUSEES PROPULSEES AU MOYEN DE L'ENERGIE NUCLEAIRE. F. Winterberg. Fusées, Mar., 1957, pp. 9-22. In French. Discussion of the present state of problems presented by nuclear propulsion. Includes: analysis of nuclear techniques and rocket techniques; consideration of the rapidly-critical gas reactor as the rocket combustion chamber; critical range of a gas reactor; nuclear-combustion gases; equations of the rapidly-critical gas reaction; energy production ratio as function of the pressure and temperature; combus-

tion time; neutron flow and pressure; radiation pressure; reaction produced by rapid fission fragments; and nuclear reactors for the direct production of electricity in terms of fission reactions.

PARACHUTES

UNITED STATES AIR FORCE PARACHUTE HANDBOOK. USAF WADC TR 55-265 [AD 118036] (OTS, PB 121934, $6.00), Dec., 1956. 310 pp. Presentation of information, test results, and other technical data pertaining to the application, design, construction, and testing of parachutes, parachute systems, and accessories. Included is a glossary of parachute terms and symbols.

PHOTOGRAPHY

DYNAMIC PHOTOELASTICITY BY MEANS OF STREAK PHOTOGRAPHY. M. M. Frocht, P. D. Flynn, and D. Landsberg. Soc. Exper. Stress Anal., Proc., No. 2, pp. 81-90. 24 refs. (Edited by C. V. Mahlmann and W. M. Murray, Cambridge, Mass., 1957. 174 pp. $6.00). Review of the literature on high-speed photography and dynamic photoelasticity. Equipment and techniques for streak photography are described and details of a new camera for obtaining dynamic photoelastic stress patterns from arbitrary lines in plane stress by this method are given. Streak-type stress patterns which show the effects of stress wave propagation are included.

PHYSICS

SOME FLOW PROBLEMS OF RARIFIED GASES. II. Zdzisław Szymański. Arch. Mech. Stosowanej (Warsaw), No. 9, 1957, pp. 35-50. Problems considered include that of the distribution of colliding molecules, a correction for the aerodynamic force due to molecule collisions, and the case of flow past a sphere. The method of calculation used to solve the last problem is described. Analytical results are compared with experimental data.

MODELES FINIS EN THEORIE DU POTENTIEL. G. Choquet and J. Deny. Inst. Advanced Study, Princeton, N.J., Rep. (AFOSR TN 57-177) [AD 126472], Apr., 1957. 71 pp. In French. Definition of the theory of the potential, considered as a study of certain defined cores in a locally compact space X, having characteristics analogous to those of the Newtonian core in the Euclidian space. Includes analysis and definition of the term "core", study of the symmetrical and degenerate cores, the theorem of duality, and applications.

DAS LICHTSUMMENGESETZ IM SICHTBAREN SPEKTRALBEREICH. O. Stierstadt and W. Swiesler. ZFW, May, 1957, pp. 150-155. 19 refs. In German Comparison of light signals of various colors and of short duration ($10 \leq t \leq 150$ m./sec.). The light sums vary between the threshold and the limit of glare, and the newly defined relative threshold (about 45%) prove to be practically independent of the color. An even higher value of about 65% relative to the darker signal is obtained with white light signals. A logarithmic relationship is found between the power of sensing the impression of brightness and the power of irritation, expressed by the light sum of the light signal (the law of light sums). This law is applicable in the range of average power of sensation and independent of the energy distribution of the source of light relative to the spectrum.

POWER PLANTS

Atomic

QUELQUES ASPECTS DE LA PROPULSION PAR L'ENERGIE NUCLEAIRE. Thomas Reis and Paul Ageron. Fusées, Mar., 1957, pp. 23-33. 32 refs. In French. Presentation of several procedures for nuclear propulsion and of problems encountered in practical application of such propulsion, including thermal cycle, attainable temperature, and protection. A preliminary study corresponding to the possibilities in the near future is presented as an illustrative example.

Jet & Turbine

MECHANISM OF CONVECTIVE HEAT TRANSFER AND ITS ROLE IN GAS TURBINES. D. G. Wilson. IME Proc., vol. 169, 1955, pp. 1,202-1,209. Theoretical investigation of the economics of different types and arrangements of heat exchangers, and consideration of methods of turbine cooling from estimates of the heat-transfer pattern around the surface of the blade. Treatment includes discussion of the fundamental dependence of convective heat transfer on the pattern of fluid flow, followed by an elementary presentation - illustrated by examples of the behavior of models - of the governing principles of fluid dynamics, particularly those concerning the boundary layer. The resultant relative levels of heat transfer from various surfaces are also discussed, together with the effect of different types of fluid.

INFLUENCE DU DISTRIBUTEUR ET DE LA TUYERE DE SORTIE SUR L'ADAPTATION D'UN TURBOREACTEUR. M. Faury. Docaéro, Mar., 1957, pp. 27-32. In French. Study of the influence of a turbine nozzle and an exhaust nozzle on matching of turbojets. Includes derivation of formulas representing the effect of cross-section variation of both nozzles on the compressor design curve, combustion chamber temperature, and thrust.

UBER DEN EINFLUSS DES LUFTZUSTANDES AUF DEN VORTRIEBSSCHUB NEUZEITLICHER TRIEBWERKE. Rudolf Schmidt. ZFW, May, 1957, pp. 139-149. In German. Method for estimating the effect of air pressure and temperature variations upon the thrust of some kinds of modern aircraft engines. The influence of the most important parameters is evaluated by systematic variation and presented along with charts for a conversion of the thrust which is often required for assessing performance flight tests. Power plants considered include the ramjet (Lorin), the turbojet (TL) with and without afterburner, and the turboprop (PTL)

Ram-Jet & Pulse-Jet

AN ANALYSIS OF HEATING PROBLEMS IN SUPERSONIC RAMJET TAILPIPES. Appendix - HEAT TRANSFER ANALYSIS. Walter Unterberg. (ARS-ASME Av. Div. Conf., Los Angeles, Mar.

14--16, 1956.) Jet Propulsion, May, 1957, pp. 514-521, 541. Analysis to predict temperatures attained by single-walled tailpipes during ground and air launch transients and at steady-state conditions in the range of flight Mach Numbers up to 4 and altitudes up to 100,000 ft. It is concluded that single-walled metal tail pipes, internally ceramic-coated where necessary, encounter a thermal barrier only in the high Mach Number and altitude region where more complex cooling means are required. Graphs show how the tail-pipe metal temperature at thermally critical locations is affected by the major variables of steady-state flight conditions, ground and air launch transients, tail-pipe exit geometry, wall thickness and wall material. Based on the analysis, engine-size effects and thermal design are discussed, and a survey is made of more complex cooling systems.

VORGÄNGE IN PULSIERENDEN STRAHLTRIEBWERKEN. Fritz Staab. ZFW, Mar., 1957, pp. 77-87. 22 refs. In German. Review of experiments on the internal processes of pulse jet engines. Results are presented for air intake, mixing, combustion, and conditions in the tube and exhaust. These results indicate that in the earlier stage of combustion, slightly luminous particles of the mixture are partly burned immediately and the rest only later, after deceleration towards the flap valve. The effects of turbulence and vibration are considerable. After a final treatise a parabola of various types of engines is given.

Rocket

ZYLINDRISCHE RAKETEN-BRENNKAMMERN. H. v. Zborowski. Raketentech. & Raumfahrtforsch., No. 1, 1957, pp. 1-3. In German. Investigation of tubular reaction chambers as a special design for rocket combustion chambers. Advantages and disadvantages of such a design are discussed in terms of its application to the decomposition of chemical propellants, as well as the advantages presented by such a design in the conversion of atomic energy.

PROPELLERS

PROPELLER SELECTION FOR HIGH STATIC AND FORWARD FLIGHT EFFICIENCY FOR VTOL AIRCRAFT. K. S. Coward. Aero. Eng. Rev., July, 1957, pp. 41--43. Development of basic equations from which curves of propeller diameter are drawn for high static and forward flight efficiency vs. cruise power, taking into account various ambient conditions, cruise take-off power and r.p.m. relations, and propeller configurations.

AN INVESTIGATION OF AERODYNAMIC FORCES GENERATED BY A PROPELLER IN A COMPRESSIBLE FLOW. Paul Lieber, Koon-San Wan, and M. Spiegel. USAF WADC TR 55-312 (OTS PB 121462, $5.00), Sept., 1955 (June, 1956). 289 pp. 10 refs. Development of a theory for the aerodynamic forces generated by three- and four-blade propellers operating at local high-subsonic and supersonic velocities. Charts are presented for finding the calculated periodic pressures thus generated. For the supersonic case, where flow is assumed to be isentropic, the periodic pressures are calculated by postulating that the supersonic section of the blade is a finite thin wing rotating about the propeller axis. The effect of shock waves formed on the supersonic sections of the blade is also calculated, using the theory of oblique shock waves and expansion waves. Treatment includes a numerical example to illustrate each calculation.

ROTATING WING AIRCRAFT

A PARAMETRIC ANALYSIS METHOD FOR ROTOR BLADE STRUCTURAL DESIGN. Alex Berman. AHS 13th Annual Natl. Forum, Washington, May 8-11, 1957, Proc., pp. 111-126. Development of expressions for rotor-blade response as functions of the basic blade parameters using the response-matrix method which gives the changes in response due to changes in the equation of motion. The effects are in-plane motion and changes in stiffness and mass distribution, in rotor speed, and in aerodynamic damping. A simpler and more accurate means of completing harmonic response matrices is also obtained. The theory is extended to allow the calculation of the changes in natural frequencies due to the above effects. The functions required for each of the effects are listed in a table.

APPROXIMATION OF ROTOR INFLOW AND FLAPWISE AIRLOAD DISTRIBUTIONS ON HINGED BLADES FROM MEASURED STRAIN AND MOTION DATA. Herbert G. Somerson. AHS 13th Annual Natl. Forum, Washington, May 8--11, 1957, Proc., pp. 51--59. 10 refs. Method in which the rotor-inflow distribution and blade flapwise-airload distribution in each significant harmonic are approximated by analysis of flapwise-bending strains measured at a number of spanwise locations, and the motions of the blade root about the flap and pitch axes. Taking into account the effects of rigid and elastic blade motion as well as the inter-harmonic coupling resulting from periodic aero-dynamic damping and spring terms, the airload distributions are found in terms of the inertia-force distributions associated with the flapwise normal modes of the rotor blades. The inflow distribution over the rotor is then found in terms of the blade-airload distribution.

ON A TYPE OF LOW-ADVANCE-RATIO BLADE FLAPPING INSTABILITY OF THREE-OR-MORE BLADED ROTORS WITHOUT DRAG HINGES. Appendix A - COMPUTATION OF NATURAL FREQUENCIES WITHOUT AIRLOADS. Appendix B - DERIVATION OF AIRLOAD TERMS JUSTIFICATION FOR USING QUASI-STATIC AIRLOADS. Appendix C - DERIVATION OF EQUATIONS OF MOTION AND OF STABILITY CRITERIA. K. H. Hohenemser. AHS 13th Annual Natl. Forum, Washington, May 8-11, 1957, Proc., pp. 72-90. 15 refs. Analysis to obtain an insight into the mechanism of flapping instability and into the trends of the stability limit when the main design and operational parameters are varied. An idealized, two-degrees-of-freedom substitute system is considered. Results indicate that the possibility of chordwise bending-flapping flutter exists for all rotors without drag hinges.

THEORETICAL AND EXPERIMENTAL STUDY OF THE COUPLED FLAP BENDING AND TORSION AERO-ELASTIC VIBRATIONS OF A HELICOPTER ROTOR BLADE. P. F. Leone. AHS 13th Annual Natl. Forum, Washington, May 8-11, 1957, Proc., pp. 91-101. Analysis employing the Myklestad method of structural vibration analysis along with oscillatory aerodynamic forces derived from two-dimensional incompressible non-stationary airfoil theory. Application is made to a typical helicopter rotor blade to determine its free and forced vibrations as affected by variations in the rotor control-system elasticity. Graphical results are presented showing the coupled normal modes for free vibrations and the zero and first six rotor harmonic components of the forced modes in high-speed level flight for forced vibrations. Comparison is made to experimental results derived from helicopter flight tests.

PHYSICAL INTERPRETATION OF HELICOPTER CHORDWISE VIBRATION. W. B. Gevarter. AHS 13th Annual Natl. Forum, Washington, May 8-11, 1957, Proc., pp. 60-71. 12 refs. Analysis to determine how freedom from ground resonance can be assured in rotor systems without drag hinges. Results show that it is possible to design tip-turbo rotor systems of relatively conventional construction that would be free of ground resonance and associated vibration problems.

APPLICATION OF BOUNDARY LAYER CONTROL TO ROTOR BLADES. S. H. Hinton. (AHS 3rd Annual Western Forum, Dallas, Oct. 9, 1956.) AHS J., Apr., 1957, pp. 36-64. Development of a boundary-layer system weighing approximately 190 lbs. and requiring 50 hp. for BLC air pumping. Flight test data show that the blade stall is essentially eliminated at forward speeds up to 13% above the "normal" blade-stall-limited speed of the test helicopter. Various power and control factors prevent higher speed from being attained. The blade stall distribution over the rotor disc, with BLC operating at the highest forward speed attained, corresponds roughly to the stall distribution with standard blades at a forward speed approximately 45% lower.

ESTIMATION OF STABILITY DERIVATIVES FROM THEORY AND FLIGHT TESTS FOR A TANDEM HELICOPTER IN FORWARD FLIGHT. Gilbert Chuck. USAF FTC TN 57-14 [AD 118720], Apr., 1957. 44 pp. Method of estimating longitudinal and lateral derivatives from theory and flight tests to be used with linearized equations of motion to represent the first approximation of the dynamic characteristics of a tandem helicopter.

HELICOPTER LONGITUDINAL STABILITY; SOME CONTRIBUTIONS TO EXISTING THEORY. P. R. Payne. Aircraft Eng., May, 1957, pp. 143-150. 14 refs. Simplified theoretical investigation to draw attention to a number of effects encountered in the study of helicopter dynamic stability. Treatment includes analysis of hovering stability and of the magnitude of the coefficients of the cubic characteristic equation which governs the motions of a disturbed helicopter; development of the theory of hovering stability for the general case of a helicopter with effective hinge restraint, taking into account the effects of lateral coupling and downwash gradient on the downwash derivatives; study of hovering stability for a helicopter with zero hinge restraint, giving the effect of all possible design variables; derivation of a theory of hovering stability for the "flying platform" helicopter; and presentation of equations for the fundamental flap-back derivatives for a rotor with effective hinge stiffness in forward flight.

SAFETY

ORIGIN AND PREVENTION OF CRASH FIRES IN TURBOJET AIRCRAFT. Appendix A - ENGINE TEMPERATURE SURVEY. Appendix B - PRELIMINARY EVALUATION OF PROBABILITY OF HOT-SURFACE IGNITION. Appendix C - METHOD OF LOCATING IGNITION ZONES WITHIN ENGINE. I. I. Pinkel, Solomon Weiss, G. M. Preston, and G. J. Pesman. US, NACA TN 3973, May, 1957. 65 pp. Experimental investigation to develop a crash-fire prevention system which de-energizes the electrical system, shuts off the fuel flow to the engine, and sprays coolant (water) over these hot surfaces. A test stand is used to simulate combustion spillage in order to determine the part played by the turbojet engine, itself, in setting the fires, and these results are confirmed by tests using actual jet aircraft.

SPACE TRAVEL

LA CONTRIBUTION DE LA GENERAL ELECTRIC COMPANY AU PROJET "VANGUARD". R. E. Small. Fusées, Mar., 1957, pp. 35-40. In French. Discussion of the Vanguard project, with a description of the satellite to be launched and its three stages. Includes description of the design and construction of the first-stage rocket, the X-405, a General Electric Co. contribution to the project Vanguard. A cross-sectional view of the X-405 is presented and difficulties encountered, due to the variation of temperature between -170° and 2,750° C. for a distance of only few inches, are outlined.

STRUCTURES

EFFECT OF CHANGING CYCLIC MODULUS ON BENDING FATIGUE STRENGTH. A. A. Blatherwick and B. J. Lazan. USAF WADC TR 56-127 [AD 110492], Oct., 1956. 118 pp. 83 refs. Study to determine, from a phenomenological point of view, the effect of changes in the cyclic secant modulus on fatigue strength. The study is confined to fatigue behavior as it is affected by observed changes in cyclic material properties without regard to the factors causing those changes. The implications of the changes are analyzed by means of hypothetical cyclic stress-strain curves. The effects of cross-sectional shape of a specimen and of loading conditions on fatigue strength are investigated through calculations based on the assumed material behavior. Two types of material are considered, one of which has strain-hardening characteristics, while the other becomes softer under repeated cycling. It is concluded that the type of material is important in determining the effect of specimen shape and type of test on fatigue strength.

USE OF CREEP TO DETERMINE THE SUM OF THE PRINCIPAL STRESSES IN TWO-DIMENSIONAL PROBLEMS. A. J. Durelli and W. F. Riley. Soc. Exper. Stress Anal., Proc., No. 2, pp. 109-116. 10 refs. (Edited by C. V. Mahlmann and W. M. Murray, Cambridge, Mass., 1957. 174 pp. $6.00). Development of a method for separating the principal stresses in two-dimensional models. The method makes use of the photoelastic isochromatics for determining the principal stress differences and of the mechanical creep properties of certain plastics to determine the sum of the principal stresses. It is shown that in a loaded model the change in thickness remains proportional to the sum of the principal stresses, and that after removal of the load the model does not return to its original thickness immediately, but recovers over a period of time. The changes during recovery are sufficiently large to permit accurate measurement to be made at all interior points of the model by means of a Leitz comparator.

ON AN ELECTRICAL ANALOGY METHOD FOR THE SEPARATION OF PRINCIPAL STRESSES ALONG STRESS TRAJECTORIES. P. S. Theocaris. Soc. Exper. Stress Anal., Proc., No. 2, pp. 11-20. 11 refs. (Edited by C. V. Mahlmann and W. M. Murray, Cambridge, Mass., 1957. 174 pp. $6.00). Method of constructing the stress trajectories directly and separating the principal stresses along these trajectories by graphical integration. The construction is obtained by applying the existing analogy between electric potential and the value of the parameter of curves representing the stress trajectories. For the separation of the principal stresses the Lamé-Maxwell equations are transformed into a form that avoids the use of isoclinics as auxiliary curves. The accuracy is confirmed by comparison with results using either the analytic method or Filon's method of graphical integration.

Bars & Rods

W SPRAWIE DOBORU OPTYMALNEGO KSZTAŁTU PRĘTÓW OSIOWO ŚCISKANYCH. Michał Życzkowski. Rozpawy Inżynierskie (Warsaw), 1956, pp. 441-456. 11 refs. In Polish. Theoretical investigation to solve the problem of defining the optimum form for axially compressed bars, assuming elastic-plastic buckling. A practical solution is obtained by limiting the choice to that of the best taper for a uniformly tapered bar (pyramid or cone); the variational problem is thus replaced by the problem of the extreme of a function of one variable. Results are presented in the form of a diagram and a chart which permit the determination of optimum taper and bar dimensions, and which show that the possibilities of material economy and weight reduction depend on the plastic characteristic of the bar. Includes an illustrative numerical example.

Beams & Columns

TRANSIENT STRESSES IN BEAMS OF VARIABLE CHARACTERISTICS. A. Robinson. Quart. J. Mech. & Appl. Math., May, 1957, pp. 148-159. 10 refs. Investigation, for a beam of variable characteristics, of the phenomenon, noted by Jones in the case of a beam of constant characteristics, of discontinuous bending moment occurring (even across the fronts of the shear waves) when a disturbance is produced by a concentrated impulse. The law of variation of the discontinuity is determined, including that applicable for the discontinuities of the shear force or bending moment across fronts of shear and bending waves, respectively. These latter cases are solved by a different method from that used by Leonard and Budiansky.

Plates

A MIXED BOUNDARY-VALUE PROBLEM IN THE ELEMENTARY THEORY OF ELASTIC PLATES. V. T. Buchwald. Quart. J. Mech. & Appl. Math., May, 1957, pp. 183-190. Derivation of a solution for plates in the form of half-planes (with the boundaries partly clamped and partly simply supported) which involves the determination of a function regular in the upper half-plane. The real part of this function is given on part of the boundary; the imaginary part on the remainder of the boundary. The method of solution is illustrated by a number of examples, some of which involve isolated loads.

LOWER BOUNDS FOR ELASTICALLY SUPPORTED MEMBRANES AND PLATES. L. E. Payne and H. F. Weinberger. U. Md. Inst. Fluid Dynamics & Appl. Math. TN BN-96 (AFOSR TN 57-176) [AD 126471], Apr., 1957. 18 pp. Analysis to define explicit lower bounds for the eigenvalues of several problems of physical interest. Such bounds are given for the vibration frequencies of elastically supported plates and membranes in terms of quantities that are easily computed.

STRESSES IN CERTAIN THIN ELASTIC PLATES ROTATING ABOUT NORMAL AXES. A. M. Sen Gupta. ZAMM, Jan.-Feb., 1957, pp. 27-34. Development of a method for solving problems pertaining to certain thin elastic plates having curvilinear boundaries and rotating steadily about normal axes. The problem of a rotating thin plate having a regular curvilinear polygonal boundary is solved to illustrate the method. Treatment includes detailed discussion of the corresponding problems of thin plates with some simpler types of boundaries.

THIN CIRCULAR PLATES SUPPORTED AT SEVERAL POINTS ALONG THE BOUNDARY. W. A. Bassali. Proc. Cambridge Philos. Soc., Apr., 1957, pp. 525-535. Theoretical investigation to obtain the deflection at any point of a thin circular plate, subjected to certain loadings along the circumference or over the area of an eccentric circle, when the plate is supported at several points along the boundary - the supports being symmetrically situated with respect to the common diameter of the plate and circle. The solutions obtained include as special cases those of Nadai and De Beer.

THE EQUILIBRIUM EQUATIONS OF THE INEXTENSIONAL THEORY FOR THIN FLAT PLATES. D. G. Ashwell. Quart. J. Mech. &

Appl. Math., May, 1957, pp. 169-182. Description of the functions of the membrane forces in the plates, deduction of the existence of shearing forces concentrated along their free edges, derivation of equations of equilibrium for estimating the magnitudes of the membrane stresses (except near the edges) and of the edge shears, and presentation of a new form of differential equation for the deformation of such a plate in terms of the edge of regression of the developable surface into which it deforms.

STRESS SOLUTIONS FOR RECTANGULAR PLATES BY CONFORMAL TRANSFORMATION. A. M. Winslow. Quart. J. Mech. & Appl. Math., May, 1957, pp. 160-168. Consideration of rectangular plates with distributed forces on the boundaries $x = \pm a$, $y = \pm b$. The x, y components of the coplanar tractions are expressed as monomials or polynomials in positive integral powers of x or y. An exact polynomial solution is combined with a solution derived by conformal transformation wherein finite summations are taken as approximate values of an infinite series to determine bounds for the approximations. Typical procedures are shown in examples for square and rectangular plates.

A REDUCTION METHOD FOR BUCKLING PROBLEMS OF ORTHOTROPIC PLATES. P. Shuleshko. Aero. Quart., May, 1957, pp. 145-156. 13 refs. Solution of several plate-buckling problems by using a reduction method with which the solution for an orthotropic plate can be reduced to that for an isotropic plate, and the solution for a plate with biaxial loading can be reduced to that for a plate with uniaxial loading, etc. Plates with simply supported ends and with various boundary conditions at the sides are considered along with uni- and biaxial loadings, and the necessary reduction equations provided.

DIE DICKE PLATTE MIT NICHTLINEARER SPANNUNGSVERTEILUNG. Eberhard Koppe. ZAMM, Jan.-Feb., 1957, pp. 38-44. In German. Consideration of a thick plate with nonlinear stress distribution in order to find an easy, general method for obtaining exact solutions starting from the invariants of the problem. The distribution functions for the displacements over the plate for two general and practically important classes of loads are calculated.

BEHANDLUNG DER PLATTENAUFGABE NACH DEM VERBESSERTEN DIFFERENZENVERFAHREN. Rudolf Zurmühl. ZAMM, Jan.-Feb., 1957, pp. 1--16. In German. Treatment of the plate problem $\Delta\Delta u = p/K$ (assuming the plate to be rectangularly bounded) by means of an improved calculus of finite differences which permits both the treatment of the boundary conditions and the determination of the second derivatives with high accuracy. Includes discussion, illustrated by numerical examples, of the application of formulas to various methods for supporting the plate, and comparison of the derived theory with known exact solutions.

Testing

DEVELOPMENTS IN THE GRID METHOD OF EXPERIMENTAL STRESS ANALYSIS. A. J. Durelli and W. F. Riley. Soc. Exper. Stress Anal., Proc., No. 2, pp. 91-100. 10 refs. (Edited by C. V. Mahlmann and W. M. Murray, Cambridge, Mass., 1957. 174 pp. $6.00). Description of a method for embedding a grid network within a sheet of photoelastic material and, by so doing, to remove many of the experimental limitations of the grid method. This method can be used for stress analysis as a complement to photoelasticity, and independently if the elastic constants of the material are known. It can also be applied to dynamic, three-dimensional and plastic deformation studies, either independently or in conjunction with photoelasticity. Results of the new method are compared with those of photoelastic measurements and electrical resistance-wire strain-gage measurements to obtain excellent agreement among the data from all three techniques.

Thermal Stress

THERMAL STRESSES IN DISKS OF CONSTANT THICKNESS. J. F. Norbury. Aircraft Eng., May, 1957, pp. 132--137. Theoretical investigation to determine the effect of temperature profile on stresses for a given temperature difference between the inner radius and the periphery of a disc of constant thickness. A power-law temperature distribution is assumed and the exponent is varied. Calculations are carried out for the continuous disc, the disc with a central hole, and the disc mounted on a shaft. In the last two cases a range of radius ratios is considered. Curves are plotted to show the variation of hoop and radial stresses at the inner radius and periphery with power-law exponent and radius ratio. The maximum shear-stress criterion is used to investigate the temperature profile required to minimize risk of failure for stationary discs subjected only to thermal stresses.

THE STRESSES IN A THIN PLATE DUE TO A NUCLEUS OF THERMOELASTIC STRAIN. Witold Nowacki. Arch. Mech. Stosowanej (Warsaw), No. 9, 1957, pp. 89-106. Theoretical investigation to determine the stresses due to discontinuous, concentrated thermal action resulting in a thin plate (treated as a two-dimensional problem) with free edges, when the temperature in the surface element $d\Omega$ is T and that of the remaining region is zero. From the solution of this problem the stresses are obtained as functions of the considered point (x, y) and the point (ξ, η) where the nucleus of thermoelastic strain acts. In this way the influence surfaces for the stresses (i.e., the Green's functions of the problem) are found. Consideration is given to the case of an infinite strip, a semi-infinite strip, and an elastic, semi-infinite plate.

O ODKSZTAŁCENIACH I NAPRĘŻENIACH TERMICZNYCH W CIENKICH PŁYTACH PROSTOKĄTNYCH I KOŁOWYCH O ZMIENNEJ GRUBOŚCI. Zygmunt Thrun. Rozprawy Inżynierskie (Warsaw), 1956, pp. 523-541. In Polish. Derivation of differential equations of deflection in Cartesian and polar coordinates for plates of arbitrarily variable

thickness, subjected to temperature arbitrarily distributed over both faces of the plates and linearly variable over the thickness. Consideration is given to rectangular plates of linearly variable thickness, which are clamped or simply supported on two edges, and to circular plates in which thickness constitutes a quadratic function. Solutions are found for the latter case and for that of a circular plate of axially symmetric rigidity.

STATIONARY TEMPERATURE FIELDS IN A TWO-LAYER PLATE. Vaclav Vodička. Arch. Mech. Stosowanej (Warsaw), No. 9, 1957, pp. 19-24. Analysis to provide a theoretical foundation for solving thermal problems of two-layer tubes. Assuming an orthogonal system of coordinates x, y, z, the steady temperature field is determined in an infinite plate parallel to the xz plane and bounded by the faces $y=y_1$ and $y=y_3$. The plate is composed of two homogeneous, isotopic layers, the surface of contact between them being $y=y_2$. Consideration is given to certain cases in which the temperature of one or both faces of the plate varies periodically in the x direction (with the period 2π) and is constant in the z direction.

THERMODYNAMICS

MODELS IN AEROTHERMOCHEMISTRY. S. S. Penner. (Accad. Naz. Lincei, 1956.) CIT Publ. No. 85, May, 1957, pp. 651-669. 32 refs. Reprint. Army-supported analysis of scaling techniques for a monopropellant liquid-fuel rocket, based on the assumption of uniform reaction throughout the chamber volume. It is shown that the linear chamber dimensions should be increased by a factor equal to the thrust ratio, and the characteristic reaction frequency must be reduced by increasing the size of the propellant droplets, the chamber diameter, and the orifice diameter by the same factor. The main problem is seen to be the control of reaction rate, and, therefore, dimensional analysis and similarity studies are made for selected combustion processes. These studies are carried out for laminar flame propagation, flash-back and blow-off of burner flames, flame stabilization on bluff bodies, burning rate of stationary liquid droplets in oxidizing atmospheres, and combustion length of enclosed turbulent jet flames.

ÜBER SYSTEME MIT CHEMISCH REAGIERENDEN KOMPONENTEN IM GLEICHGEWICHT. I - DIE BERECHNUNG DER GEMISCHZUSAMMENSETZUNG. H. J. Kaeppeler and G. Baumann. (7th Internatl. Astron. Cong., Rome, Sept., 1956.) Astronautica Acta, Fasc. 1, 1957, pp. 28-46. 22 refs. In German. Analysis based on statistical considerations of chemical reactions in equilibrium in order to find the equilibrium constants for such reactions in the isothermal isochoric and isothermal-isobaric cases. Relations also are given for the calculation of equilibrium constants from tabulated values of the thermodynamic functions for individual gases. In addition a system of equations is derived for an arbitrary number of components and for an arbitrary number of chemical reactions, and a generalized method of solution is given for this system.

Combustion

A THEORY OF INFLAMMABILITY LIMITS AND FLAME-QUENCHING. D. B. Spalding. Proc. Royal Soc. (London), Ser. A, Apr. 24, 1957, pp. 83-100. 15 refs. Solution of energy and diffusion equations for a one-dimensional, laminar, steady combustion wave in a premixed gas which is in heat-transfer communication with solid surroundings. It is shown that, in general, a given combustible mixture has two possible flame speeds, but the lower one represents a normally unstable condition. If the heat-loss parameter increases, the two flame speeds first become coincident and then imaginary. The condition of coincidence is identified with the inflammability limit. Particular examples are evaluated in which heat loss is caused, in turn, by radiation and by conduction to the walls of a tube.

ZUR THEORIE STATIONÄRER FLAMMEN IN STRÖMENDEN GASEN. K. H. Schramm. DVL Bericht No. 31, Apr., 1957. 22 pp. 11 refs. Westdeutscher Verlag, Köln & Opladen. In German. Study of the theory of steady flames in flowing gases. Includes discussion covering the flame front and the flow field in the case of steady combustion in a rotationally symmetric pipe flow. The combustion zone is represented schematically as infinitely thin, i.e., the overall combustion area is presumably composed of two zones, one of which contains the unburnt mixture and the other the exhaust alone. Both areas are separated by a discontinuity line - the flame front. The flowing gas, both burnt and unburnt, is considered as a physically homogeneous medium or an ideal gas. Friction and heat transfer are neglected. Differential equations for the flow function and the flame front, tied together by the boundary condition of the flow at the flame front, are derived by considering the entropy. The function of the boundary value is obtained, and an iteration method is suggested for its numerical integration.

INTERMITTENT DETONATION AS A THRUST-PRODUCING MECHANISM. J. A. Nicholls, H. R. Wilkinson, and R. B. Morrison. Jet Propulsion, May, 1957, pp. 534-541. 10 refs. Investigation of the feasibility of a reaction device operating on intermittent gaseous detonation waves. Preliminary experiments are made by suspending the detonation tube as a pendulum. A cyclic detonation tube is designed and operated utilizing hydrogen-air mixtures. Measurements of thrust, fuel flow, air flow, and temperatures are obtained over a range of operating conditions.

INVESTIGATION OF JET FLAMEHOLDERS. Appendix A - THEORETICAL PREDICTION OF DEFLECTION OF A JET ENTERING A FLUID STREAM. Appendix B - THEORETICAL PREDICTION OF THE WAKE WIDTH OF AN OPPOSED JET. R. H. Eustis and C. L. Mraz. USAF WADC TN 56-316 [AD 97-142], Apr., 1956 (1957). 63 pp. Study of the effect of fluid jets in stabilizing combustion in a premixed stream. The investigation

includes analysis of the fluid flow in the region of the jet, a water-channel study of jet mixing, and combustion experiments in a 2-in. -diam. tube. The parameters investigated include injection angle of the stabilizing jet (transverse or opposed), jet pressure, jet tube diameter, jet fluid composition, and jet air temperature. Results show that a transverse air jet is ineffective for flame stabilization under the conditions investigated, but that opposed jets are effective. Stabilization can be effected by jet flows of considerably less than 1% of the main stream flow.

Heat Transfer

NATURAL-CONVECTION HEAT TRANSFER FROM A HORIZONTAL CYLINDER ROTATING IN AIR. David Dropkin and Arieh Carmi. (Heat Transfer & Fluid Mech. Inst., Stanford, June 21--23, 1956.) Trans. ASME, May, 1957, pp. 741-749. Experimental investigation to determine the effect of rotation on the heat-transfer coefficient at various Reynolds Number values. Use is made of two hollow copper cylinders, one 4.5 in. and another 3.25 in. in outside diameter, which are nickel plated to minimize the heat transfer by radiation and internally heated by electric-cartridge heaters. Surface temperatures are obtained by thermocouples peened to the inside surface, and the experimental procedure involves systematic investigation of each dimensionless parameter previously determined by dimensional analysis.

VTOL & STOL

THE LIMITATIONS OF A WING FOR LOW SPEED FLIGHT. J. B. Nichols. AHS 13th Annual Natl. Forum, Washington, May 8-11, 1957, Proc., pp. 24-32. Development of a generalized method of analysis which considers the low-speed characteristics of both VTOL and STOL aircraft on an equal basis. A generalized aircraft type is chosen which, by mere parameter variation, can be changed from a conventional airplane to a VTOL aircraft. The results indicate that the power required to fly very slowly, as is necessary in STOL operations, is so high that the additional power required to attain full VTOL capabilities appears very reasonable, particularly in view of the low weight penalty involved with the use of modern turbine power plants.

WIND TUNNELS & RESEARCH FACILITIES

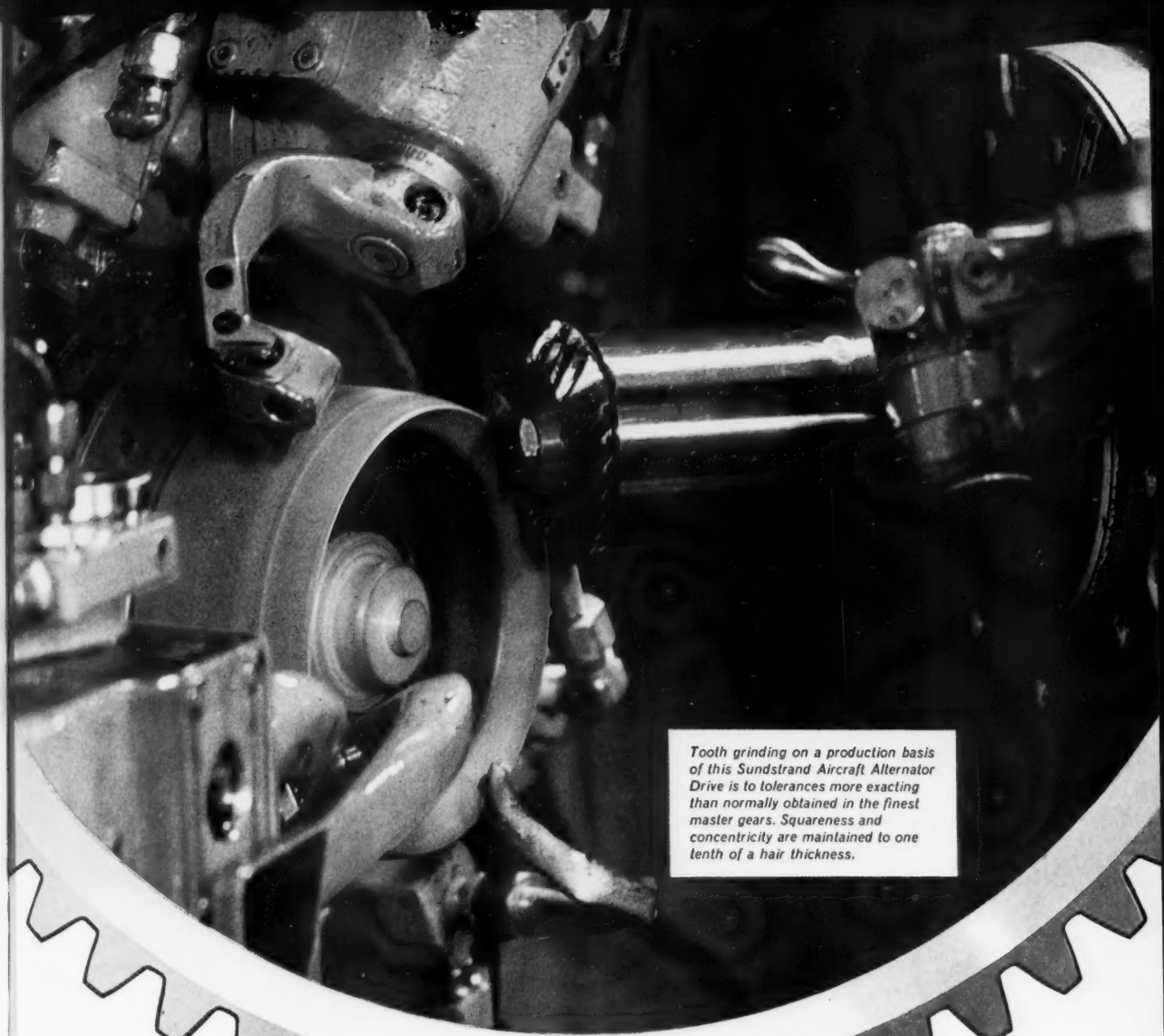
MACH NUMBER MEASUREMENTS IN HIGH-SPEED WIND TUNNELS. J. A. F. Hill, J. R. Baron, L. H. Schindel, and J. R. Markham. NATO AGARDograph 22, Oct., 1956. 113 pp. 81 refs. (Paris, NATO AGARD. U.S. Distribution by NACA, Wash., D. C.) Discussion of both sub- and supersonic Mach Number measurements in air from the point of view of calibration measurements of an empty wind tunnel, of local Mach Number measurements at points in the flow field around a model, and of free-flight Mach Number simulation in the presence of wall interference. Includes consideration of errors in deducing Mach Numbers from particular measurements and recommendation of certain measuring procedures.

WALL INTERFERENCE IN A PERFORATED WIND TUNNEL. Riccardo Brescia. (Atti Accad. Sci. Torino, 1952-1953.) US, NACA TM 1429, May, 1957. 28 pp. Translation. Extension of the theory concerning cascades composed of a series of flat plates placed one behind the other, to the case where the impinging stream is nonuniform. The deduced properties of this cascade flow are applied to the study of the wall interference between such a cascade-like boundary and a vortex-source type of singularity. Ultimately, the interference arising from an arbitrary general singularity placed symmetrically between two perforated walls is analyzed and the results are used to determine the particular kinds of wall geometry that will produce no interference effects in the cases of a slender lifting wing and of a symmetrical profile having a finite thickness.

DEVELOPMENT OF SUBSONIC AND SUPERSONIC TOTAL TEMPERATURE PROBES FOR A BLOW-DOWN TYPE WIND TUNNEL. G. L. Alexander. Texas U. DRL Rep. 399 (AFOSR TN 57-164) [AD 126456], June, 1957. 45 pp. 10 refs. Experimental investigation to develop subsonic probes of small mass and relatively low conductive heat loss, and a supersonic heated-shield probe. In both the sub- and supersonic cases it is shown that the probes can perform with less than 0.5% error and maintain this high rate of accuracy over wide ranges of temperature variations and transient conditions.

FLUCTUATIONS AND HOT-WIRE ANEMOMETRY IN COMPRESSIBLE FLOWS. Appendix - FORMULAS RELATED TO NONLINEAR TEMPERATURE VARIATION. M. V. Morkovin. NATO AGARDograph 24, Nov., 1956. 102 pp. 62 refs. (Paris, NATO AGARD. US. Distribution by NACA, Wash., D.C.) Analysis of the problem of extracting information from a hot-wire anemometer. Treatment is based on the concept of local linearization around each operating point of an otherwise nonlinear system. A general formula is derived for the direct voltage sensitivities with respect to the fluctuation modes of vorticity, entropy, and sound. The sensitivity expressions specialize for different speed ranges and serve as a basis for evaluating the potentialities and the actual performance of the hot wire as a turbulence indicator, a thermometer, and a microphone. Procedures for the different speed ranges are outlined and their probable accuracy is assessed.

OPTICAL METHODS FOR EXAMINING THE FLOW IN HIGH-SPEED WIND TUNNEL. I - SCHLIEREN METHODS, D. W. Holder and R. J. North. II - INTERFEROMETER METHODS, G. P. Wood. NATO AGARDograph 23, Nov., 1956. 148 pp. 168 refs. (Paris, NATO AGARD. U.S. Distribution by NACA, Wash., D. C.) Review of optical methods for observing the changes of refractive index which accompany the changes of density that are present in flow past the model at high Mach Number. Emphasis is placed on the use of schlieren, direct-shadow, and interferometer techniques, but brief details of other methods in the early development are given.



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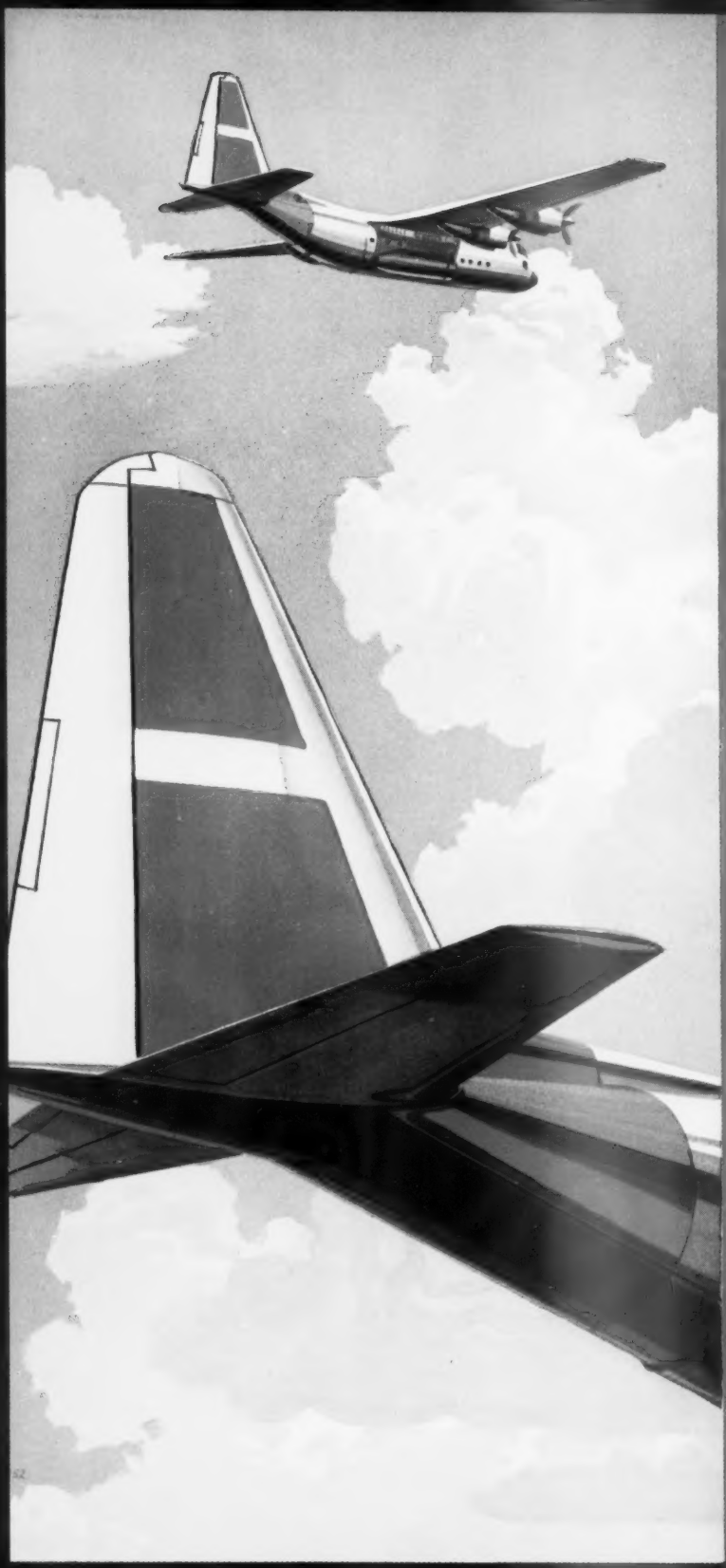

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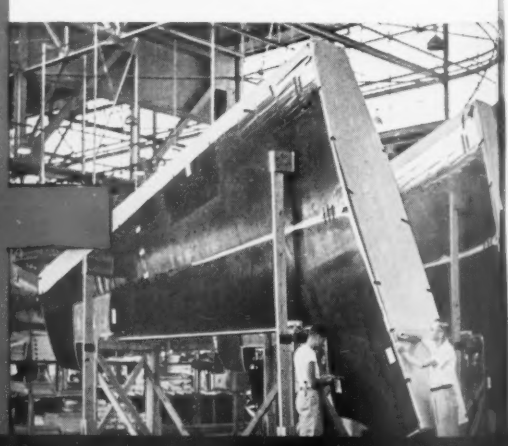

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statistical analysis of the resulting correlograms and spectra, which, although different in magnitude from the conventional, varies similarly to the ordinary scale and is easier to evaluate.

Wings & Airfoils

Investigation of the Effects of Leading-Edge Chord-Extensions and Fences in Combination with Leading-Edge Flaps on the Aerodynamic Characteristics at Mach Numbers from 0.40 to 0.93 of a 45° Sweptback Wing of Aspect Ratio 4. Kenneth P. Spreemann and William J. Alford, Jr. *U.S., NACA TN 3845,* Apr., 1957. 45 pp. Tests in the Langley high-speed 7 × 10-ft. wind tunnel to obtain lift, drag, and pitching-moment data for all configurations.

A Collection of Data for Zero-Lift Damping in Roll of Wing-Body Combinations as Determined with Rocket-Powered Models Equipped with Roll-Torque Nozzles. David G. Stone. *U.S., NACA TN 3955,* Apr., 1957. 23 pp. 14 refs. Experimental determination of the zero-lift damping-in-roll derivative through high-subsonic, transonic, and low-supersonic speeds. Data is collected for three semispan-wing configurations to show the effects of wing plan form and airfoil section and, qualitatively, of aeroelasticity.

A Special Method for Finding Body Distortions that Reduce the Wave Drag of Wing and Body Combinations at Supersonic Speeds. Harvard Lomax and Max. A. Heaslet. *U.S., NACA Rep. 1282,* 1956. 38 pp. 16 refs. Supt. of Doc., Wash., $0.35. Analysis of the problem of shaping an adjoining fuselage for a given wing and supersonic Mach Number so that the combination will have a low wave drag.

Theoretical Investigation of the Effects of Configuration Changes on the Center-of-Pressure Shift of a Body-Wing-Tail Combination due to Angle of Attack and Mach Number at Transonic and Supersonic Speeds. J. Richard Spahr. *U.S., NACA TN 3966,* May, 1957. 43 pp.

Aeroelasticity

Influence of Thermal Stresses on the Aeroelastic Stability of Supersonic Wings. M. A. Biot. (*Cornell Aero. Lab. Rep. SA-987-S-2,* Apr., 1956.) *J. Aero. Sci.,* June, 1957, pp. 418–420, 429. Investigation to evaluate the effect of thermal stress on the chordwise bending, the anticlastic effects, and the nonlinear aspects due to finite deformation.

Nonlinear Phenomena. C. A. Ludeke. (*ASME-AIEE Conf., Princeton, Mar. 26–28, 1956.*) *Trans. ASME,* Apr., 1957, pp. 439–443; Discussion, pp. 443, 444. 11 refs. Presentation of phenomena associated with nonlinear systems, including wave form, frequency dependence on amplitude, the jump phenomenon, subharmonic oscillations, limit cycles, and frequency entrainment. Experimental examples are given along with a representative bibliography.

Applicazione del Metodo di Broglio ad Alcune Questioni Riguardanti le Vibrazioni Flessionali delle Travi. Paolo Santini. *Cen. Consult. Stud. Ric. Aero. Mil., Monogr. Sci. Aero.,* Dec., 1956, 34 pp. In Italian. Application of the Broglio method to some problems of flexural vibration of beams.

Flutter Research at the Royal Aircraft Establishment Farnborough. H. Templeton. *NATO AGARD Rep. 4,* Sept., 1955. 30 pp. 20 refs. Discussion of the objectives and main activities of flutter research. Work includes development of more accurate theories for calculating oscillatory aerodynamic forces and of high-speed computational aids especially suited to flutter calculations.

Flutter Model Testing at Transonic Speeds. W. P. Targoff and R. P. White, Jr. (*IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 706.*) *Aero. Eng. Rev.,* June, 1957, pp. 58–62.

Flutter Prediction in Practice. E. G. Broadbent. *NATO AGARD Rep. 44,* Apr., 1956. 29 pp.

Measurement of the Aerodynamic Forces on Oscillating Aerofoils. W. G. Molyneux. *NATO AGARD Rep. 35,* Apr., 1956. 30 pp. 35 refs.

Problems in Computation of Aerodynamic Loading on Oscillating Lifting Surfaces. H. C. Garner and W. E. A. Acum. *Gt. Brit., ARC CP 309* (Apr. 30, 1956). 1957. 15 pp. 38 refs. BIS, New York, $0.45. Formal discussion of the linearized theories of oscillating wings in subsonic and supersonic flow, with consideration given to the computability of the subsonic problem when Mach Number, frequency, and aspect ratio are arbitrary and when any one of these parameters takes extreme values. Includes outline of methods for treating flutter problems.

Substantiation of Safe Fatigue Life for Rotorcraft. Appendix I—**Ad Hoc Rig Testing.** Appendix II—**Sequence of Ground Testing Recommended by the Air Registration Board.** W. A. P. Fisher. *Gt. Brit., ARC CP 317,* 1957. 18 pp. Presentation of a comprehensive development and testing system.

Supports for Vibration Isolation. W. G. Molyneux. *Gt. Brit., ARC CP 322,* 1957. 19 pp. Description of spring arrangements that provide flexible supports of very low stiffness for a limited range of movement and are suitable for vibration isolation provided the levels of vibration are not too large. Includes discussion of some particular applications of the arrangements for vibration isolation and in other fields.

Aeronautics, General

Air Operations Problems in the Vicinity of Metropolitan Areas. Charles E. Rosendahl. *SAE Natl. Aero. Meeting, New York, Apr. 2–5, 1957, Preprint 108.* 18 pp. Discussion of public reactions to aircraft noise and fear of accidents in residential areas around large airports.

Needed Research for Machine Information Systems. John W. Kuipers. *NATO AGARD Rep. 47,* Feb., 1956. 18 pp. 23 refs.

Operational Problems Requiring Documentation Research. Verner W. Clapp. *NATO AGARD Rep. 48,* Feb., 1956. 7 pp.

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Special Issue: Luftfahrttechnik. *VDI Zeitschrift,* Apr. 11, 1957, pp. 471–497. 252 refs. In German. *Partial Contents:* Aerodynamik, Fritz W. Riegels. Von Flugplätzen unabhängige Schnellflugzeuge, Heinrich Hertel. Starrflügler, E. Wilhelm Pleines. Hubschrauber, Walter Just. Unbemannte Flugkörper, Eugen Sänger. Kleinluftschiffe, Wolfgang Mejer. Festigkeitsfragen bei Flugzeugen, W. Thielemann. Triebwerksanlagen, Otto Lutz. Flugkraftstoffe und Flugschmierstoffe, Günter Spengler and H. O. Hössi. Schwerwerkstoffe in der Luftfahrttechnik, Heinrich Wiegand. Kunststoffe im Flugzeugbau, Peter Hoppe. Regelungen in Flugzeugen, Gerald Klein. Fernlenkung, Richard Eppler. Flugsicherung, Otto Heer. Includes such subjects as aerodynamics, VTOL and STOL aircraft, military and civil aviation, rotating wing aircraft, unmanned vehicles, structures, engines, fuels and lubricants, control, and safety.

Special Issue: Review of Research and Development for Canada's Aircraft Industry. *Aircraft* (Canada), Mar., 1957. 29 pp. *Partial Contents:* Research and Development in Canada, An Assessment. Centre for Aeronautical Science. Scientific Partner in Defence. Flight Research at Uplands. An Indispensable Tool. Dollars from Development, H. R. Foottit. Research and Development in Canada's Aircraft Industry. Matching Machines to Man. There is No Limit.

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Planning of Research and Development. William L. Swager. *Battelle Tech. Rev.,* May, 1957, pp. 3–8. Discussion pointing out how cooperative planning, involving the entire organization, can increase the effectiveness of research and development.

Air Transportation

Ex.-Jet Transport. II. Stanley H. Evans. *The Aeroplane,* Apr. 5, 1957, pp. 478, 479.

Problems of Jet Transport Operation—An Appraisal by T.C.A. I, II. J. T. Dyment. *Flight,* Mar. 29, Apr. 3, 1957, pp. 400, 401; 437, 438. Abridged. Consideration of airport, meteorological, and traffic-control requirements.

Turboprop Efficiency for Short-Stage Airlines. D. M. Desoutter. *Aeronautics,* Apr., 1957, pp. 26–39. Description of the Fokker Friendship, and aircraft especially designed to meet the needs of short-stage air lines.

Air Freight in Competition with Motor Transport. Grover Loening. *Aero. Eng. Rev.,* June, 1957, pp. 70–73.

The Economics of the Supersonic Transport. *The Aeroplane,* Mar. 29, 1957, pp. 437, 438. Discussion of technical trends in civil aviation and of the prospects for economical operation on the next supersonic development "plateau."

Effect of Hot Day Performance on Jet Transport Economics. D. W. Finlay. *SAE Natl. Aero. Meeting, New York, Apr. 2–5, 1957, Preprint 93.* 10 pp.

The Influence of Range, Speed and Lift-Drag Ratio on the Operating Costs of a Civil Aircraft. R. G. Thorne. *Gt. Brit., RAE TN Aero.2487,* Nov., 1956. 9 pp. Graphical method of presenting the influence of range, speed, specific fuel consumption, lift-drag ratio, and basic operational weight ratio on the direct operating costs of jet-propelled civil aircraft.

Growth of Available Seat Mile Capacity in World Scheduled Operations from 1954 to 1962. J. H. Hamelet. *Canadair SED Rep. 95,* Jan. 27, 1956. 25 pp. Charts giving the year-by-year, zone-by-zone effect on available seat-mile capacity of the new aircraft delivered during the preceding year. A method is described for finding the total seat-miles available each year from the data in the charts.

Airplane Design

Britannia—A Roundup. James H. Stevens. *Aircraft* (Canada), Apr., 1957, pp. 14, 15, 17, 19, 75–77 ff. Description of the aircraft, with details of some of the more unusual design features. The causes and effects of the vicissitudes encountered in the development of the Britannia are also discussed.

The Whispering Giant. *Aerial,* Apr., 1957, pp. 5–7. Description of the communications equipment installed on BOAC Britannia aircraft.

Progress with the P.1; Britain's Principal Fighter Programme. W. T. Gunston. *Flight,* Apr. 26, 1957, pp. 541–545. Review of the principles underlying the design of Britain's P.1B experimental fighter aircraft, and discussion of factors affecting its development.

Building the E.P.9; Simple and Ingenious Methods for Quantity Production of the Edgar Percival Agricultural Aircraft. *Flight,* Apr. 5, 1957, pp. 440–443, 446.

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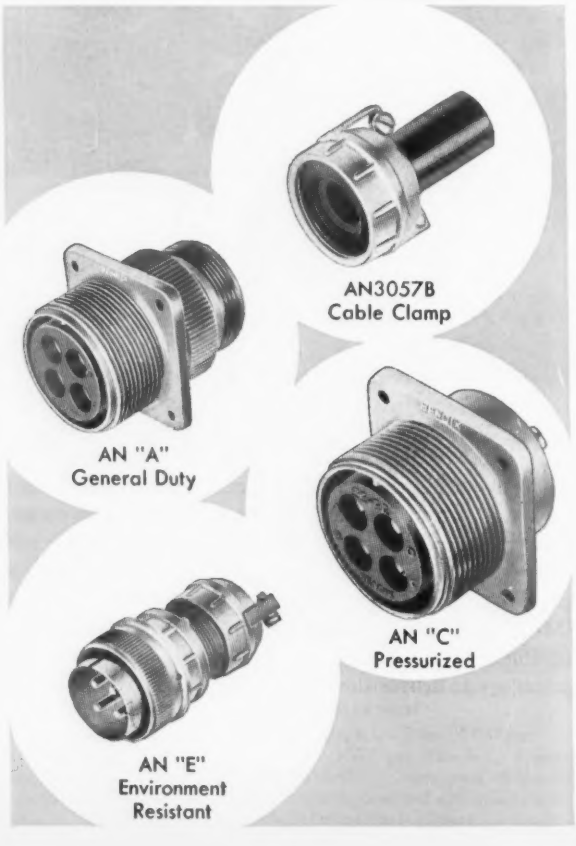

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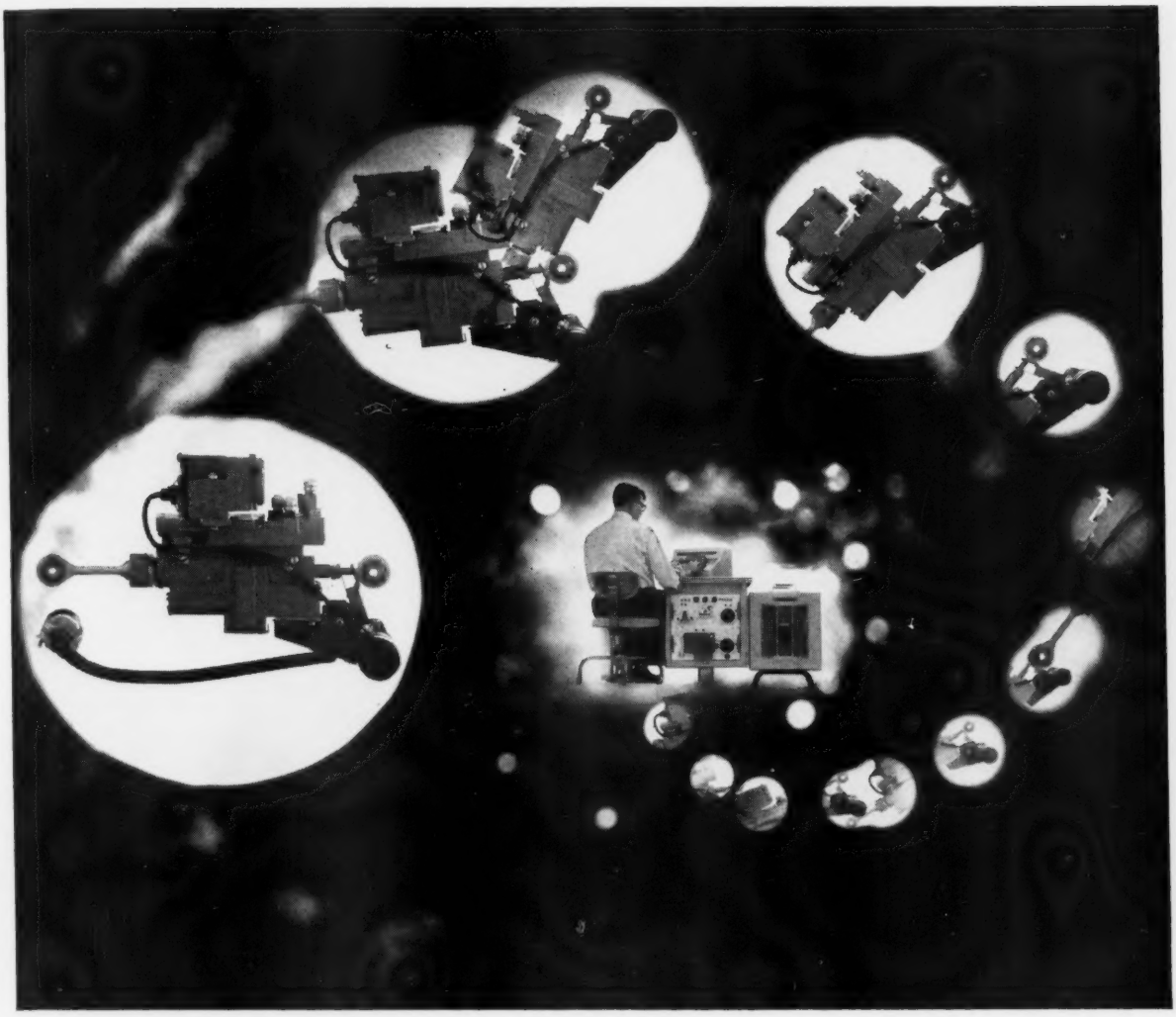

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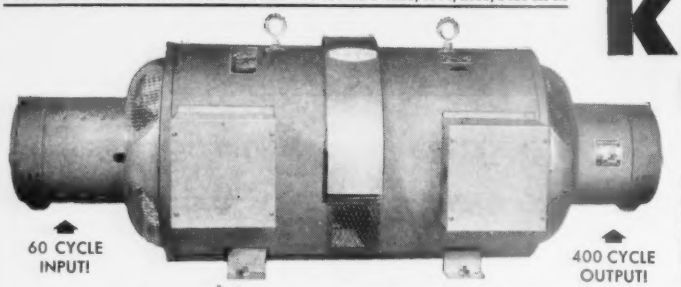

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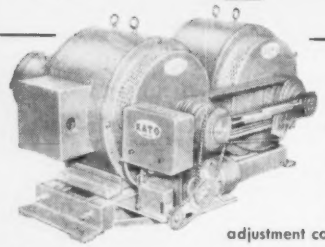

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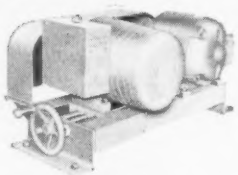

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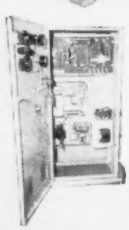

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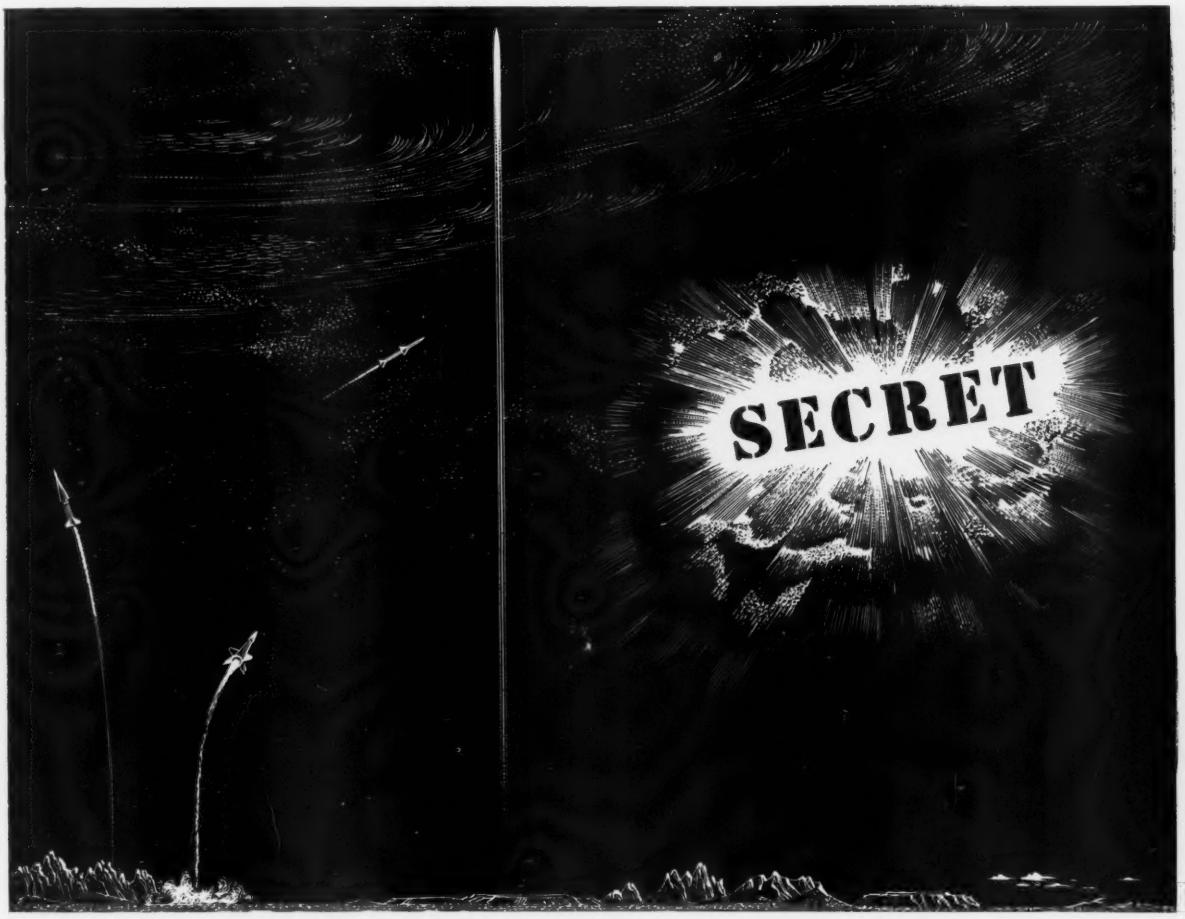

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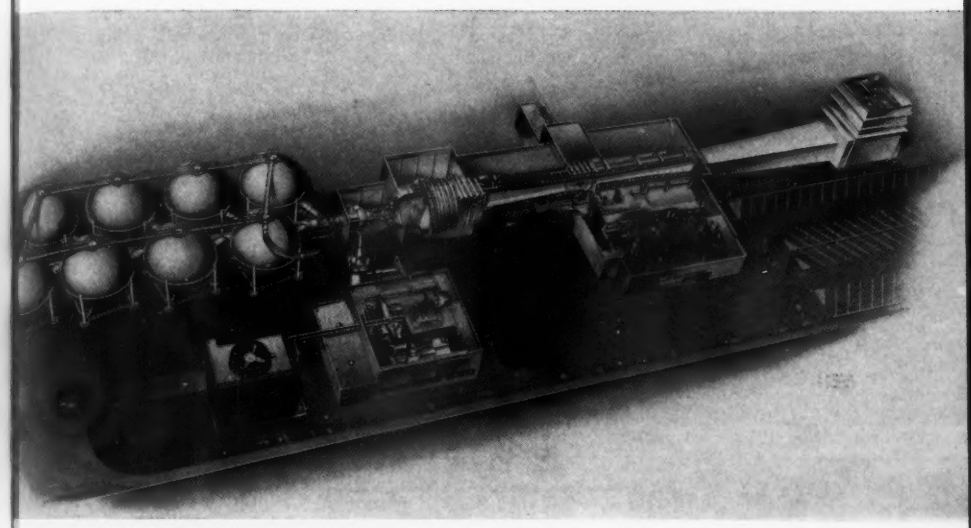

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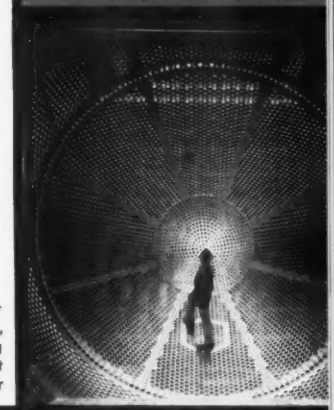
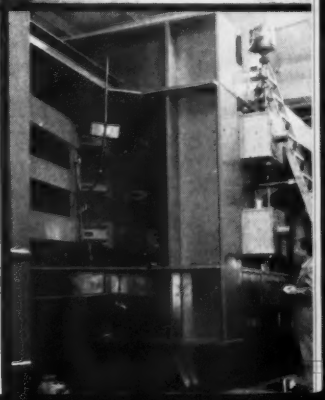


Diffuser screen, modifying air blast to muffler



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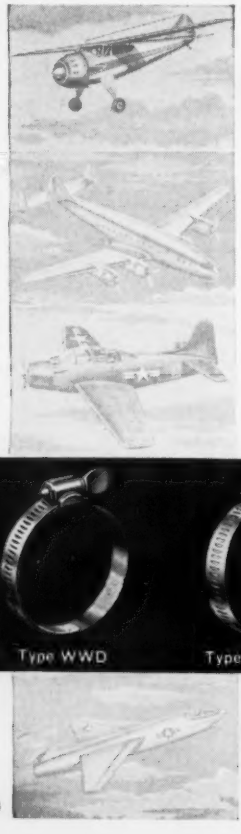

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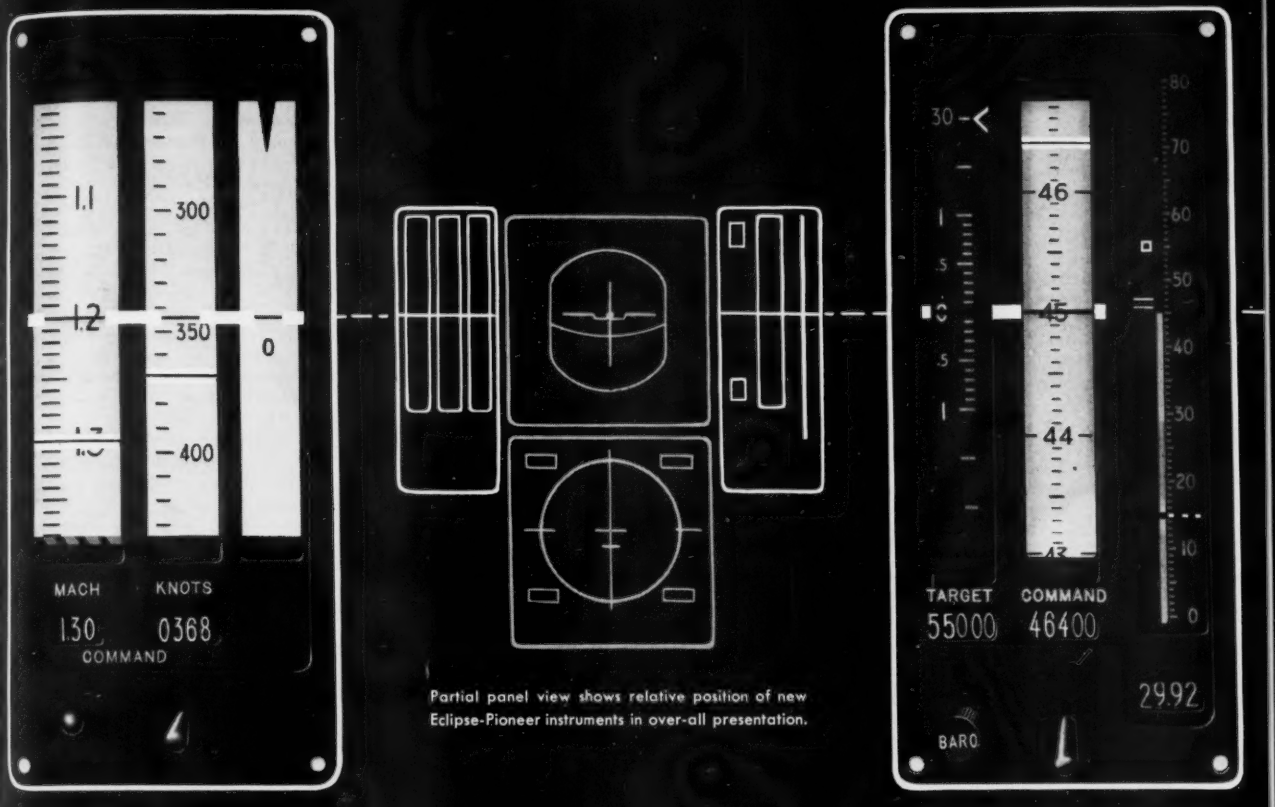

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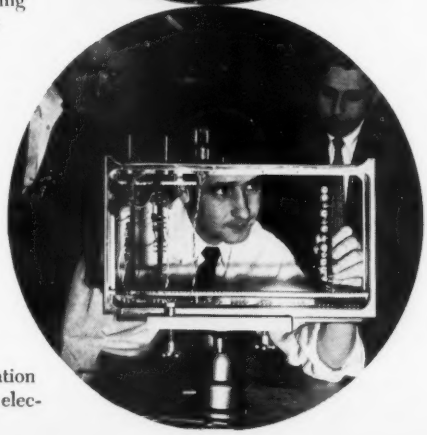

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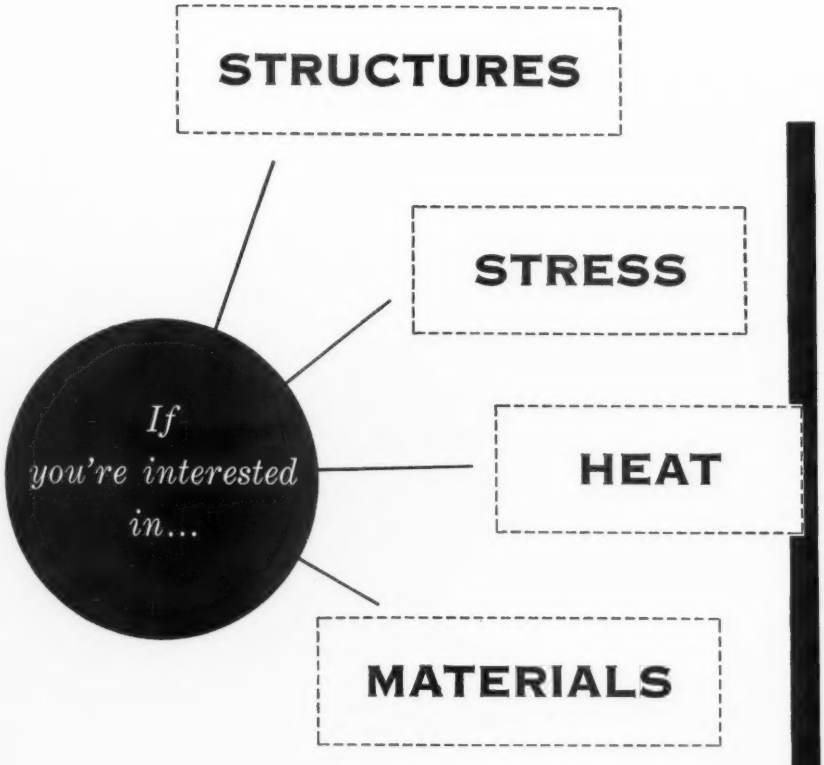

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MISSILE SYSTEMS THERMODYNAMICS

Weapon systems activities under Lockheed's management are encountering thermodynamic problems of a most advanced nature. Projects at the Palo Alto, Sunnyvale and Van Nuys organizations present unusual scope for achievement in thermodynamics areas including: Boundary layer and heat transfer analyses in hypersonic flow fields such as pressure gradient and real-gas effects; analysis of thermodynamic performance of missiles in continuum flow, slip flow and free-molecular flow; calculation of transient structural and equipment temperatures resulting from aerodynamic heating and radiation; specification of ground tests and flight tests required to verify and improve thermodynamic design of missile and weapon systems; analysis and interpretation of thermodynamic ground test and flight test data. Inquiries are invited. Please address the Research and Development Staff, Palo Alto 21, California.

Aerothermodynamic Staff members discuss heat flux during reentry of a hypersonic vehicle. Left to right: J. I. Osborne, aerodynamics; R. G. Wilson, thermodynamic research; W. E. Brandt, thermodynamic analysis; Dr. L. H. Wilson, Thermodynamic Section head.

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OSR-supported theoretical investigation to describe irreversible processes by considering a model which permits the construction of Gibbs-type ensembles for open systems not in equilibrium.

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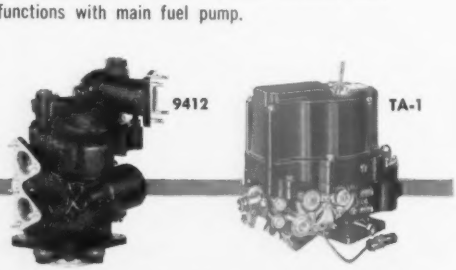

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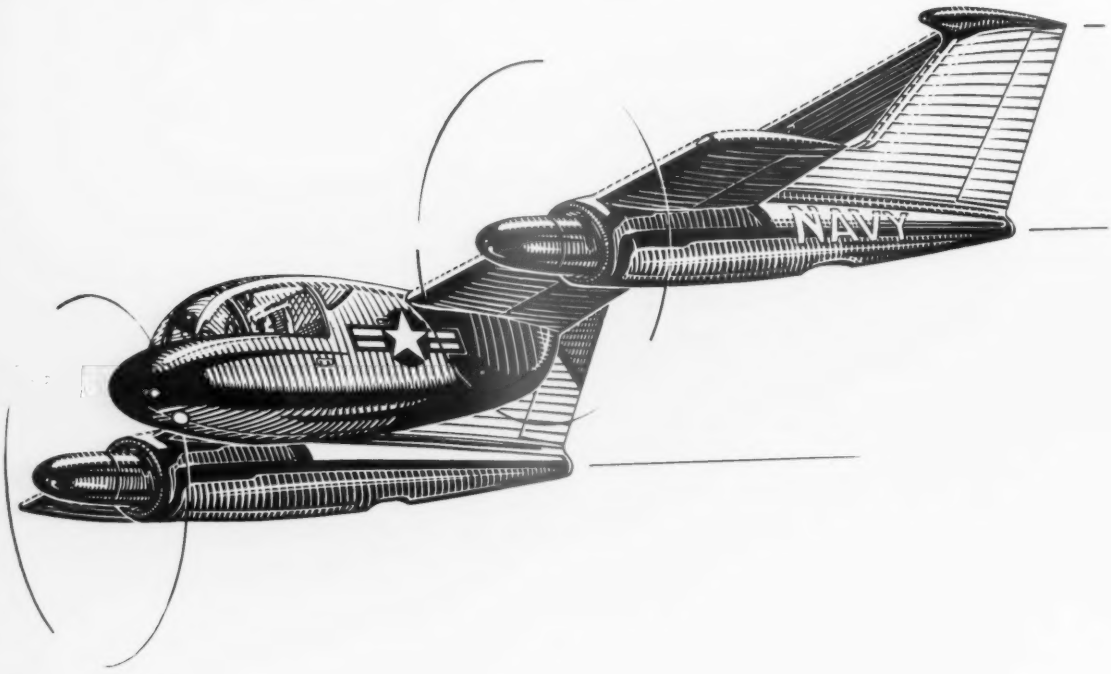

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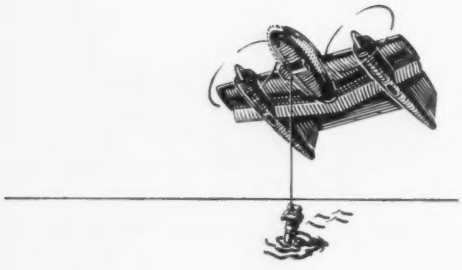

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Annual Natl. Forum, Washington, May 8–11, 1957, Proc., pp. 39–42. Discussion, in relation to human impact-force tolerance, of the need for crashworthy design and delethalization of VTOL aircraft. Crash-safety factors are reviewed, and recommendations for crash-safety designs are proposed.

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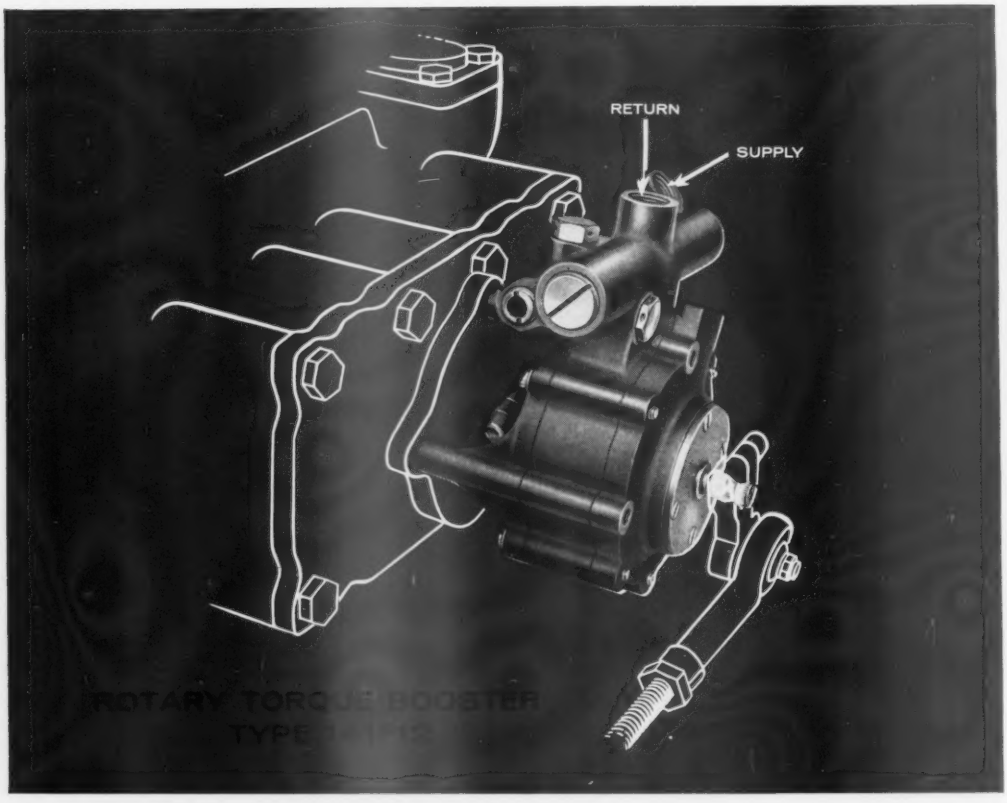

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Aeronautical Reviews — BOOKS

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A Textbook of Sound; Being an Account of the Physics of Vibrations with Special Reference to Recent Theoretical and Technical Developments. A. B. Wood. 3rd Rev. Ed. London, G. Bell and Sons, Ltd., New York, The Macmillan Company, 1955. 610 pp., illus., diagrs., tables. $6.75.

The newer material added to this revision of the 1941 edition includes various aspects of ultrasonics, hearing, noise, and technical applications. Intended to fulfill the requirements of students preparing for university degrees, the book has further utility as a reference to the applied aspects of the subject. The author is on the staff of the Admiralty Research Laboratory, Teddington, England.

AGRICULTURAL AVIATION

Handbook on Aerial Application in Agriculture. College Station, Texas, Short Course Office, Texas A.&M. College, December, 1956. 146 pp., illus., diagrs., tables. $2.50.

The important experimental and practical developments during the past few years in aerial application are here summarized as a text for the instruction of applicator pilots and will be of use to farmers and designers of agricultural aircraft and equipment. The information on aircraft, equipment, operation techniques, distribution problems, insect and disease control, chemicals, fertilizing, and seeding is intended for general application, but the specific treatments recommended in this volume are for the areas in and around Texas with its subtropical, moist coastal, medium rainfall, and high arid conditions.

AIRPORTS

Minutes of the Ninth Annual Airport Development and Operation Conference, Syracuse, N.Y., October 16, 1956. Sponsored by the State of New York. Albany, Dept. of Commerce, New York State, 1956. 92 pp.

Contents: Planning for Jet Operations, William Littlewood. Pilots and Mechanics—Where Do We Get Them, Samuel Freeman. The Coming Age of Space Flight, Kurt Stehling. Helicopters and Heliports, Panel Discussion. The Zahns Story, Edwin J. Lyons. Civil Air Patrol Programs, Victor E. Moore. Air Traffic Control, Randall H. Carpenter.

AVIATION MEDICINE

The Problems of Vision in Flight at High Altitude. Thomas C. D. Whiteside. (NATO, AGARD, AGARDograph No. 13.) London, Butterworths Scientific Publications; New York, Interscience Publishers, Inc., 1957. 162 pp., illus., diagrs., tables. $5.00.

The purpose of this contribution to aeromedical literature is to examine the visual problems associated with flight at high altitudes, though not necessarily high speeds, as they affect passengers and air crews. It refers in general to flight in the stratosphere or in the upper limits of the troposphere, not at specific heights above sea level but always above cloud. The author attributes these problems to two basic physical causes. One is the reversal of light distribution at high altitude where the bright sky—formed by cloud and haze—is below and the darker blue sky is above. The other is the clear blue sky which is frequently present in the hemisphere above the horizon—a sky without trace of cloud and constituting an empty visual field. The reversed light distribution is responsible for glare problems, particularly with regard to visibility in the cockpit; the clear blue sky for problems associated with vision outside the cockpit—judgment of speed, size, and distance of target, and particularly air-to-air search. Dr. Whiteside is a member of the Institute of Physiology, University of Glasgow, and of the Royal Air Force Institute of Aviation Medicine, Farnborough.

Contents: (1) Introduction: Historical Survey. (2) Effects of Changes in Intensity and Spectral Distribution of Sunlight at High Altitude: Contrast Between Light and Shade. Fluorescence in the Lens of the Eye. Intraocular Scatter of Light. (3) Physiological Changes Affecting Visibility of Objects Inside the Cockpit: Anoxia. Glare. (4) Physiological Factors Affecting Air-to-Air Visibility: Amount of Accommodation Exerted Involuntarily in an Empty Visual Field. Rate of Relaxation of Accommodation. The Relation of the Effectiveness of a Stimulus at the Far Point to its Angular Distance from the Fovea. Comparison of the Effectiveness of Six Collimated Patterns in Bringing Out Accommodation for Infinity. Effect of Empty Field Myopia Upon the Minimum Visual Angle for a Distant Target. (5) Discussion: Glare. Search. (6) Conclusions and Appendixes. References.

COMPUTERS

Automatic Coding; Proceedings of the Symposium held January 24-25, 1957, The Franklin Institute, Philadelphia. (Monograph No. 3.) Philadelphia, The Franklin Institute, April, 1957. 118 pp., diagrs., tables. $3.00.

Contents: Automatic Coding at G.E., Richard M. Petersen. Systems of Debugging Automatic Coding, Charles Kata. PRINT 1—An Automatic Coding System for the IBM 705, Robert W. Bemer. The Procedure Translator—A System of Automatic Programming, Henry M. Kinzler and Perry M. Moskowitz. OMNICODE—A Common Language Programming System, Russell C. McGee. A Matrix Compiler for UNIVAC Laurence C. McGinn. A Mathematical Language Compiler, Alan J. Perlis and Joseph W. Smith. A Mechanized Approach to Automatic Coding, E. C. Yowell.

DESIGN

System Engineering: An Introduction to the Design of Large-Scale Systems. Harry H. Goode and Robert E. Machol. New York, McGraw-Hill Book Company, Inc., 1957. 551 pp., illus., diagrs., tables. $10.

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The main purpose of this book is to provide engineers with sufficient technical background to qualify them for service with a system-design team whose primary function is to make decisions involving choices of equipment for specific purposes and to illustrate the use of tools such as statistics, computers, game theory, and information theory in solving large-scale engineering problems. Examples of these are the development of radar systems, telephone systems, and guided missile systems. The author deals primarily with equipment systems which are automatic in nature and have broad application in the fields of transportation, communications, commerce, industry, science, and military weaponeering. The approach to the subject is practical rather than abstract and presupposes a mathematical background in elementary calculus. Numerous examples are given of the applications of the theories discussed; problems illustrating these theories, with their solutions, are supplied at the back of the book. Both of the authors are with the University of Michigan.

Contents: (1) Introduction: Complexity—The Problem. Examples of Large-Scale Systems. An Integrated Approach to System Design. (2) Probability—The Basic Tool of Exterior System Design: Fundamental Notions. Distributions of Discrete Variables. Distributions of Continuous Variables. Characteristics and Distributions of Statistics. Stability and the Laws of Large Numbers. (3) Exterior System Design: Origin and Formulation of the Problem. Mathematical Models. Design of Experiments—Data Gathering. Analysis of Experiments—Mathematical Statistics. An Example of Exterior System Design. (4) Computers—The Basic Tool of Interior System Design: Introduction to Computers. Components of Electronic Digital Computers. Operation of Digital Computers. Components of Analog Computers. Operation of Electromechanical Analog Computers. Input-Output Equipment. Comparison of Analog and Digital Techniques. (5) Interior System Design: Solution of the Problem—Steps and Tools. Single Thread—System Logic. High Traffic—Queueing Theory. Competitive Aspects—Game Theory. Guides to System Design—Linear Programming, Group Dynamics, and Cybernetics. Simulation. Component Parts of the System. Communications—Information Theory. Reflexive Control—Servomechanism Theory. Input—Output—Human Engineering. (6) Epilogue: Economics, Test and Evaluation, and Management. References. Solutions to Problems. Index.

DOCUMENTATION

Documentation in Action. Jesse H. Shera, Allen Kent, and James W. Perry. Based on 1956 Conference on Documentation at Western Reserve University. New York, Reinhold Publishing Corporation, 1956. 471 pp. $10.

The papers that make up this volume give a detailed account of the science and art of effectively organizing and utilizing recorded information. Recent advances in documentation systems, the equipment involved, and the role of re-

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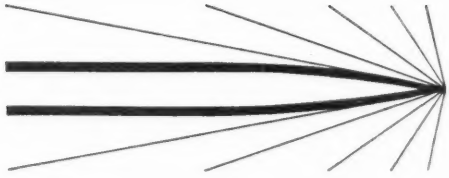
ELECTRONICS

Electronic Components Handbook: Resistors, Relays, Capacitors, Switches. Editors: Keith Henney and Craig Walsh. Sponsored by the Electronic Components Laboratory, WADC, USAF. New York, McGraw-Hill Book Company, Inc., 1957. 244 pp., illus., diagrs., tables. $9.00.

The detailed data furnished in this handbook on resistors, capacitors, relays and switches are calculated to assist designers of military and commercial electronic equipment in the selection and



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An Introduction to Semiconductors. W. Crawford Dunlap, Jr. New York, John Wiley & Sons, Inc., 1957. 417 pp., illus., diagrs. $11.75.

This extensive treatment of the subject of semiconductors includes basic concepts, properties of materials, methods of measurement, and applications. The approach to the material is almost entirely physical, with details and mathematics kept to a minimum, while formal theory is largely supplanted by the terminology and ideas employed by workers in the field. The author, who is Supervisor—Solid State Research, Research Laboratories, Bendix Aviation Corporation, has intended the book for the engineer, technician, and research worker interested in a source of general information about the subject and for the senior or graduate student who wishes to supplement his course work in solid-state theory.

Contents: (1) Introduction. (2) Some Facts About Crystals and Their Structure. (3) Theory of the Solid State. (4) Imperfections in Crystals. (5) Statistical Mechanics for Metals and Semiconductors. (6) The Electron Theory of Metals and Semiconductors. (7) Contact and Surface Properties of Semiconductors. (8) Properties of *p-n* Junctions. (9) Experimental Measurements on Semiconductors. (10) General Methods of Preparing Semiconductor Materials. (11) Properties of the Elemental Semiconductors. (12) Semiconducting Compounds. (13) Rectifiers. (14) Transistors. (15) Photocells, Thermistors, Hall Effect, and Other Semiconductor Applications.

Radio Electronics. Samuel Seely. New York, McGraw-Hill Book Company, Inc., 1956. 487 pp., illus., diagrs., tables. $7.00.

A methematically detailed exposition of the essential processes and important circuits in the field of radio communications in which emphasis has been placed on the physical and mathematical analysis of various systems. The treatment of feedback amplifiers and the use of the radio detector and the Bradley detector in frequency modulation detection is particularly extensive. A complete chapter is devoted to information theory as it relates to different types of transmission systems. This book is a companion volume to the author's *Electronic Engineering*, both of which represent a revision and extension of his *Electron-Tube Circuits*. Much of the material in these pages originated in courses taught by Professor Seely at Syracuse University. He is presently with the Department of Electrical Engineering, Case Institute of Technology.

Contents: (1) Introduction to Communication Systems. (2) Characteristics of Electron Tubes. (3) Rectifiers and Filters. (4) Vacuum Triodes as Circuit Elements. (5) Basic Amplifier Principles. (6) Untuned Potential Amplifiers. (7) Special Amplifier Considerations. (8) Untuned Power Amplifiers. (9) Tuned Potential Amplifiers. (10) Tuned Power Amplifiers. (11) Oscillators. (12) Amplitude Modulation. (13) Demodulation. (14) Frequency Modulation and Detection. (15) Information Theory. Appendix A: Notes on General Network Analysis. Appendix B: Plate Characteristics of Vacuum Tubes. Appendix C: Characteristics of Transmitting Tubes. Appendix D: Table of Bessel Functions of the First Kind. Index.

ENGINEERS

Engineers Employed by Private Practitioners, Survey Report. Washington, National Society of Professional Engineers, 1957. 40 pp., diagrs., tables. $1.00.

Based on data from questionnaires returned by consulting firms, this survey contains basic information on salaries, hours, fringe benefits, geographical distribution of employees, size of firms, status, grades, overtime practices, etc., in the engineering profession.

LIGHTER-THAN-AIR

The Zeppelin in the Atomic Age. Edwin J. Kirschner. Urbana, University of Illinois Press, 1957. 80 pp., illus., diagrs., tables. $3.50.

This brief study of lighter-than air craft presents a strong case for the further redevelopment of airship transportation which has generally been in eclipse since the hydrogen-filled Hindenburg burst into flames at Lakehurst, N.J., 20 years ago. By way of introduction to his subject the author reviews the past history of aerostat flight from the crude balloons of the Montgolfier brothers to the huge commercial carriers of Germany's DELAG and the U.S. Navy's ill-fated fleet dirigibles, the Akron and the Macon. The engineering characteristics of rigid airships as they relate to hull structure and power plants are explained as is the equipment necessary in both flight and ground operations. The technical performance and operational requirements of normal military and commercial airships also are detailed; the author points out that they are essentially low-altitude aircraft whose navigation and control characteristics approximate those of surface vessels rather than airplanes. The major lifting gases are described, and, in a brief reference to foreign technical research, certain recommendations concerning structures, power plants, and route operations are made.

The future of airship development is dealt with in chapters devoted to the economic feasibility of rigid lighter-than air transport, the probable extent of the national defense interest, and the role of international organizations in promoting worldwide communication and transportation networks.

Statistics for the hypothetical operation of various-size dirigible fleets including rates, fares, and costs are supplied and an analysis of the comparative performance of airplanes and airships is presented. The use of nuclear power for propulsion drive also comes under discussion. Mr. Kirschner proposes the establishment of a national transportation agency in which lighter-than-air craft would be given equality with other types of vehicles so as to furnish an entirely new system of air transportation, as well as adding valuable auxiliaries to the Armed Services in times of emergency.

The potential use of airships as "aircraft carriers of the air," as air refueling tankers, troop carriers, hospital ships, submarine hunters, and radar pickets is put forward as sufficient reason for their inclusion in the national defense armory.

The use of airships to implement the "open skies" plan is proposed as a logical intermediate step between scanning by jet photo-reconnaissance planes and observation by space satellites capable of transmitting information to ground observers.

The author, who is on the air staff of the U.S. International Cooperation Administration, closes his study with a lengthy bibliography of airship literature which includes books and reports, periodical articles, and publications of governmental organizations.

MATHEMATICS

Mathematics for Electronics, with Applications. Henry M. Nodelman and Frederick W. Smith.

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1957 Aeronautical Engineering Catalog

See Page 163 For Details

New York, McGraw-Hill Book Company, Inc., 1956. 391 pp., illus., diagrs., tables. $7.00.

The emphasis in this volume is on application rather than on mathematical theory. *Part 1* describes the methods by which mathematics has been used in electronics. *Part 2* introduces dimensional analysis and shows the methods which can be used to check the validity of engineering equations and formulas independent of the engineering considerations used to establish such equations. *Part 3* deals with the algebra of determinants and matrix algebra. *Part 4* presents the fundamental properties of series approximations, the prediction of behavior of nonlinear electronic devices, and the processes of harmonic generation and intermodulation. *Part 5* gives solutions of differential equations employing both classical and Laplace transform methods. *Part 6* includes elements of Boolean algebra and material on switching circuits. Accompanying the text is a complete set of up-to-date problems based on current engineering practice. Designed for use in industry and engineering college courses, the material requires a background of elementary calculus, physics, and elementary electrical network theory. Mr. Nodelman is Head, Mathematics and Physics Department, RCA Institutes, and Instructor in Mathematics, Polytechnic Institute of Brooklyn; Mr. Smith is a television engineer with the National Broadcasting Company.

Modern Mathematics for the Engineer. Edited by Edwin F. Beckenbach. New York, McGraw-Hill Book Company, Inc., 1956. 514 pp., diagrs., tables. $7.50.

This collection of articles by specialists in their fields presents a broad survey of the application of advanced mathematical thought to the expanding technology of today. Emphasis has been placed on the importance of stochastical analysis, the theory of games, operations analysis, and linear, nonlinear, and dynamic programing in modern engineering. The methods and applications of the new high-speed computation procedures are extensively covered. Each of the chapters encompasses the mathematical formulation of physical problems and constructive methods of their solution. The textbook is the second in a series based on engineering extension lectures given at the University of California, Los Angeles.

Contents: Part 1, Mathematical Models: (1) Linear and Nonlinear Oscillations, Solomon Lefschetz. (2) Equilibrium Analysis: The Stability Theory of Poincaré and Liapunov, Richard Bellman. (3) Exterior Ballistics, John W. Green. (4) Elements of the Calculus of Variations, Magnus R. Hestenes. (5) Hyperbolic Partial Differential Equations and Applications, Richard Courant. (6) Boundary-Value Problems in Elliptic Partial Differential Equations, Menahem M. Schiffer. (7) The Elastostatic Boundary-Value Problems, Ivan S. Sokolnikoff. *Part 2, Probabilistic Problems:* (8) The Theory of Prediction, Norbert Wiener. (9) The Theory of Games, H. Frederic Bohnenblust. (10) Applied Mathematics in Operations Research, Gilbert W. King. (11) The Theory of Dynamic Programming, Richard Bellman. (12) Monte Carlo Methods, George W. Brown. *Part 3, Computational Considerations:* (13) Matrices in Engineering, Louis A. Pipes. (14) Functional Transformations for Engineering Design, John L. Barnes. (15) Conformal Mapping Methods, Edwin F. Beckenbach. (16) Nonlinear Methods, Charles B. Morrey, Jr. (17) What Are Relaxation Methods?, George E. Forsythe. (18) Methods of Steep Descent, Charles B. Tompkins. (19) High-Speed Computing Devices and Their Applications, Derrick H. Lehmer. Name Index. Subject Index.

Methods in Numerical Analysis. Kaj L. Nielsen. New York, The Macmillan Company, 1956. 382 pp., diagrs., tables. $6.90.

The analysis of tabulated data and the numerical method of finding the solutions to equations are the two main categories of numerical analysis treated in this elementary university textbook. The mathematical aspects are treated in a simple manner, and emphasis is placed on the methods which are easily adapted to automatic desk calcu-

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lators. Since many of the numerical methods derived in the book are easily performed with the aid of tables, the necessary tables have been included as part of the volume. Both classical procedures and recently developed methods are presented in the nine chapters that describe fundamentals, finite differences, interpolation, differentiation and integration, Lagrangian formulas, ordinary equations and systems, differential and difference equations, least squares and their application, and periodic and exponential functions. Dr. Nielsen is Head, Mathematics Division, U.S. Naval Ordnance Plant, Indianapolis.

MECHANICS

Statistical Mechanics, Principles and Selected Applications. Terrell L. Hill. New York, McGraw-Hill Book Company, Inc., 1956. 432 pp., diagrs., tables. $9.00.

This treatise consists of a review of the basic theory of the equilibrium theory of statistical mechanics and its applications to the solution of the fundamental problems of physical chemistry and chemical physics. Though not all topics in the field have been covered, comprehensive treatment has been given to a selected group in which there has been considerable advancement since 1940: fluctuation theory, imperfect gas and condensation theory, distribution functions, nearest-neighbor (Ising) statistics, and free-volume and hole theories of liquids and solids. The text has been designed primarily for graduate students and research workers in theoretical chemistry and physics. References to supplementary reading are provided for the material covered in each chapter. The author is now with the Naval Medical Research Institute, Bethesda, Md.

Contents: (1) Principles of Classical Statistical Mechanics. (2) Principles of Quantum Statistical Mechanics. (3) Statistical Mechanics and Thermodynamics. (4) Fluctuations. (5) Theory of Imperfect Gases and Condensation. (6) Distribution Functions and the Theory of the Liquid State. (7) Nearest-Neighbor Lattice Statistics. (8) Lattice Theories of the Liquid and Solid States. Appendixes. Index.

METALS & ALLOYS

Applied Metallurgy for Engineers. Malcolm S. Burton. New York, McGraw-Hill Book Company, Inc., 1956. 407 pp., illus., diagrs. $7.50.

The author's aim is to present a broad but concise view of the science and art of metals engineering which will bridge the gap between principles and practices. To this end his approach has been to develop the background of the science of metals which is the theoretical basis of applied metallurgy and to outline the application of these principles in the fields of casting, metalworking, welding, heat treatment, and powder metallurgy. The topics under discussion include the nature of metals and their production, methods of examining and testing metals, the nature of alloys and alloying, and the function of equilibrium diagrams in heat treating and other processing methods.

Mr. Burton, who is associated with the School of Chemical and Metallurgical Engineering, Cornell University, has based his work on 10 years' experience in teaching applied metallurgy at Cornell and has written it specifically to be used as a college text for students in all branches of engineering.

Phase Diagrams in Metallurgy, Their Development and Application. Frederick N. Rhines. New York, McGraw-Hill Book Company, Inc., 1956. 340 pp., illus., diagrs., tables. $12.

Twenty years of lectures given at the Carnegie Institute of Technology form the basis of this treatment of the application of phase diagrams to metallurgical problems. A preliminary chapter discusses unary (one-component) systems which provide the base for diagrams of all multicomponent systems. Individual chapters are devoted to the following binary systems: isomorphous, eutectic, eutectoid, monotectic, peritectic, peritectoid, and syntectic. The three component ternary systems described in separate chapters

are those of the isomorphous systems—the three-phase equilibrium, and the four-phase equilibrium, classes I, II, and III. For both the binary and ternary systems consideration is given to congruent transformation and to diagrams of complex configuration. The concluding chapters deal with quaternary and quinary systems, and the determination of temperature-composition diagrams. Dr. Rhines, who is associated with the Aluminum Company of America, is Professor of Light Metals and staff member of the Metals Research Laboratory, Carnegie Institute of Technology, and has prepared this work as a text for the undergraduate engineering student.

Symposium on Solder. Presented at the 59th Annual Meeting, American Society for Testing Materials, Atlantic City, N.J., June 19–20, 1956. (ASTM Special Technical Publication No. 189.) Philadelphia, ASTM, 1957. 190 pp., illus., diagrs., tables. $3.00.

Contents: Solder, Fluxes, and Techniques for Soldering Aluminum, J. D. Dowd. Ultrasonic Soldering of Aluminum, J. Byron Jones and John G. Thomas. Dip Soldering Printed Circuits, E. S. Miller and A. A. Johns, Jr. Soldering in Semiconductor Devices, W. F. Lootens. Industrial Survey of Paste Solder Alloys, H. R. Williams. Corrosive Fluxes—Their Role in Soldering, Robert M. MacIntosh. The Use of Rosin and Activated Rosin Fluxes, Frederick C. Disque, Jr. Soldering Fluxes and Flux Principles, A. Z. Mample. Non-Corrosive Fluxes, Evaluation of Spread and Corrosion Properties, H. C. Sohl. A Method for Testing and Evaluating the Joint Properties of a Copper Liner Soldered in an Aluminum Casting, M. V. Davis. The Performance of Some Soft Solders at Elevated Temperatures and Pressures, H. E. Pattee and R. M. Evans. Dip-Solder Printed Circuit Joint Characteristics, Alfred A. Johns, Jr., and E. S. Miller. "Tin Disease" in Solder Type Alloys, Alfred Bornemann. Gray Tin Formation in Soldered Joints Stored at Low Temperature, W. Lee Williams. Proposed Numerical Evaluation System for Soft Solders, Solder Fluxes, and Solderability, L. Pessel. Controlling Quality on Soldered Electrical Connections, W. H. Rombach. Symposium Summation, G. H. Harnden.

NUCLEAR ENERGY

Nuclear Reactors for Research. Edited by Clifford K. Beck. (Geneva Series on the Peaceful Uses of Atomic Energy; James G. Beckerley, Editor.) Princeton, N.J., D. Van Nostrand Company, Inc., 1957. 267 pp., illus., diagrs., tables. $8.50.

This guide to the present status of research reactor technology is the third volume in the series summarizing the technical information contained in key papers delivered at the Geneva Conference in 1955. The information given on specific types of reactors includes physical descriptions, design principles, operating history, special problems, and other related data. Natural-uranium, graphite-moderated research reactors, heavy water heterogeneous reactors, "Water Boilers," MTR types, reactors of the Soviet Union, and fast-neutron reactors are all covered in detail. The uses and performance of each type in physics, chemical engineering, and biological research as well as the factors affecting reactor choice are clearly presented.

Dr. Beck is Scientific Advisory to the Director, Civilian Applications Division, United States Atomic Energy Commission.

POWER PLANTS

International Jet Engine Overhaul Symposium, 1st, Evendale, Ohio, November 14–16, 1956. Cincinnati, Aircraft Gas Turbine Division, General Electric Company, 1956. 111 pp., illus., diagrs.

Contents: The USAF Scale of Jet Engine Overhaul, R. L. Arstingstall. Technical Support of Overhaul, M. K. Wolfson. Field Repair of Turbojet Engines, Commander Dean H. Swain. Mechanical Cleaning, John Donat. Overhaul Cleaning Methods and Future Trends, John McCabe.

PRODUCTION

Motion Economy and Work Measurement. Robert Lee Morrow. 2nd Ed. New York, The Ronald Press Company, 1957. 468 pp., illus., diagrs., tables. $7.50.

Originally published in 1946 as *Time Study and Motion Economy* and of proved value to the student and practicing engineer, the present edition has been expanded to cover in detail the area of work sampling and motion economy. Stressing techniques and their application, the book includes the latest material on fatigue measurement, standard data, micromotion study, training of time study men, automatic machine work assignment, work sampling techniques and their application to work simplification, setting of time standards, and control of manufacturing operations. All procedures described have been tested in practice at many types of manufacturing plants and can be readily adapted and applied to any production problem. The author has been consulting engineer for a number of years and now is Lecturer, Department of Industrial and Management Engineering, Columbia University.

SPACE TRAVEL

A Casebook on Soviet Astronautics. F. J Krieger. (U.S. Air Force. Project RAND, Research Memorandum RM-1760.) Santa Monica, Calif., The RAND Corporation, June 21, 1956. 244 pp., diagrs.

In this working paper prepared by a staff member of The RAND Corporation an attempt is made to judge the extent of Soviet scientific and popular interest in astronautics as it may be determined from Russian writings on the subject. The historical, scientific, and technical aspects of rocketry are dealt with in a four-part bibliography containing books by and about early Russian proponents of astronautics, books of a popular science nature, monographic works, and periodical articles. By far the larger part of this casebook is taken up by translations from the Russian of articles (mostly 1954, 1955) selected from a variety of periodicals which interpret the problems of cosmic flight and the possible uses to which this mastery may be applied. The majority of the references supplied are for 1950–1955.

Contents: Introduction. Bibliography. Appendixes: (1) The Way to the Stars, V. Borisov. (2) Flight to the Moon, M. K. Tikhonravov. (3) Is a Moon Rocket Being Built in the Soviet Union, Heinz H. Kölle. (4) Trip to the Moon: Fantasy and Reality, Kirill Stanyukovich. (5) Item on Interplanetary Communications from *Bol'shaya Sovetskaya Entsiklopediya*. (6) On the Way to the Stars, N. A. Varvarov *et al.* (7) Problems of Interplanetary Flights, K. Stanyukovich. (8) Gold Medal Established for Outstanding Work in the Field of Interplanetary Communications. (9) Problems of Cosmic Flight A. A. Shternfel'd. (10) Commission on Interplanetary Communications. (11) Problems of Flight into Cosmic Space, N. Varvarov. (12) Problems of Astronautics, V. G. Fesenkov. (13) An Artificial Satellite of the Earth, K. Stanyukovich. (14) Cosmic Laboratory, Interview with A. G. Karpenko. (15) The Artificial Earth Satellite, Interview with G. I. Pokrovskii. (16) Discovery of a World, Book Review by N. Varvarov. (17) Problems of Cosmic Flights, A. G. Karpenko and G. A. Skuridin. (18) On Flights into Space, Discussion with L. I. Sedov. (19) The Road into the Cosmos, Yu. S. Khlebtsevich. (20) Problems of Weightlessness, P. K. Isakov. (21) A Table of Soviet Missiles, Alfred J. Zaehringer.

THERMODYNAMICS

Elements of Engineering Thermodynamics. Rolf H. Sabersky. New York, McGraw-Hill Book Company, Inc., 1957. 318 pp., illus., diagrs. $7.50.

In this text, designed for a first course in thermodynamics, three of the four distinct empirical laws used to make predictions about the physical behavior of matter are stated and their experimental foundations discussed; these are the zeroth (0th) law and the first and second laws of thermodynamics. The author, Associate Professor of Mechanical Engineering, California Institute of Technology, employs the classical approach in his treatment; matter is regarded as continuous and not as consisting of individual molecules.

In illustrating the applications of thermodynamics to various engineering problems, the industries which at present employ the largest number of engineers were particularly considered. Numerous problems have been included in the text whose solutions are essential for a full development of the subject.

Contents: (1) Introduction. (2) The Zeroth Law and the Concept of Temperature. (3) Dimensions and Units. (4) Definitions and Terminology. (5) The First Law of Thermodynamics. (6) Special Processes of a Simple System. (7) A System in Motion. (8) The Second Law of Thermodynamics. (9) Corollaries of the Second Law. (10) Availability. (11) The Properties of a Perfect Gas. (12) Properties of a General Substance. (13) Van der Waal's Gas. (14) Cycles Using Gas as Working Substance. (15) Cycles Using a Condensible Fluid as Working Substance. (16) Some Economic Considerations Regarding Power Equipment. (17) Some Jet-Propulsion Cycles. (18) The Flow of a Compressible Fluid. (19) Some Simple Flow-Measuring Devices. (20) Some Special Phenomena in Compressible Flow. (21) Flow Through a Nozzle. (22) Elements of Turbine Design. (23) Elements of Combustion. Appendixes. Index.

Thermodynamics. Virgil Moring Faires. 3rd Ed. New York, The Macmillan Company, 1957. 543 pp., illus., diagrs., tables. $7.50.

The present edition of a work formerly entitled *Applied Thermodynamics* has been extensively rewritten. It is intended to serve as a satisfactory undergraduate terminal course in the theoretical treatment of thermodynamics with enough applications to make possible a comprehensive understanding of the subject and to prepare the student for advanced study. The author is Professor of Mechanical Engineering, North Carolina State College.

UPPER ATMOSPHERE RESEARCH

Rocket Exploration of the Upper Atmosphere. Edited by R. L. F. Boyd and M. J. Seaton in Consultation with H. S. W. Massey. (Journal of Atmospheric and Terrestrial Physics, Special Supplement, Vol. 1.) London, New York, Pergamon Press, 1954. 376 pp., illus., diagrs., tables. $15.

This special supplement is a report on the first major international scientific conference of the postwar years to survey the techniques employed and the results obtained from rocket exploration of the upper atmosphere. Sponsored jointly by the U.S. Upper Atmosphere Research Panel and the Gassiot Committee of the Royal Society of London, the conference had as its main topic the work carried out by various agencies in the United States. Nearly 50 papers were presented which fell into three rough categories: the measurement of common physical properties and chemical constitution of the air; investigations of radiations from the sun and primary cosmic radiations, which are not observable at sea level; and observation of phenomena induced in the atmosphere by incoming radiation. Certain techniques, other than rocket exploration, are also described in several papers devoted to laboratory studies of the behavior and phenomena of the upper atmosphere.

Contents: (1) Upper Air Research by Use of Rockets in the U.S. Air Force, M. O'Day. (2) Day Airglow Measurements with Rocket-Borne Photometers, J. F. Bedinger. (3) Ambient Temperature Determinations from Yawing Rockets in the Presence of Winds, R. A. Minzner, M. Dubin, and E. W. Beth. (4) Meteor Impacts by Acoustical Techniques. (5) Utilization of the V-2 (A-4) Rocket in Upper Atmosphere Research, C. F. Green. (6) The High Altitude Sounding Rocket, M. W. Rosen and R. B. Snodgrass. (7) The Inexpensive Attainment of High Altitudes

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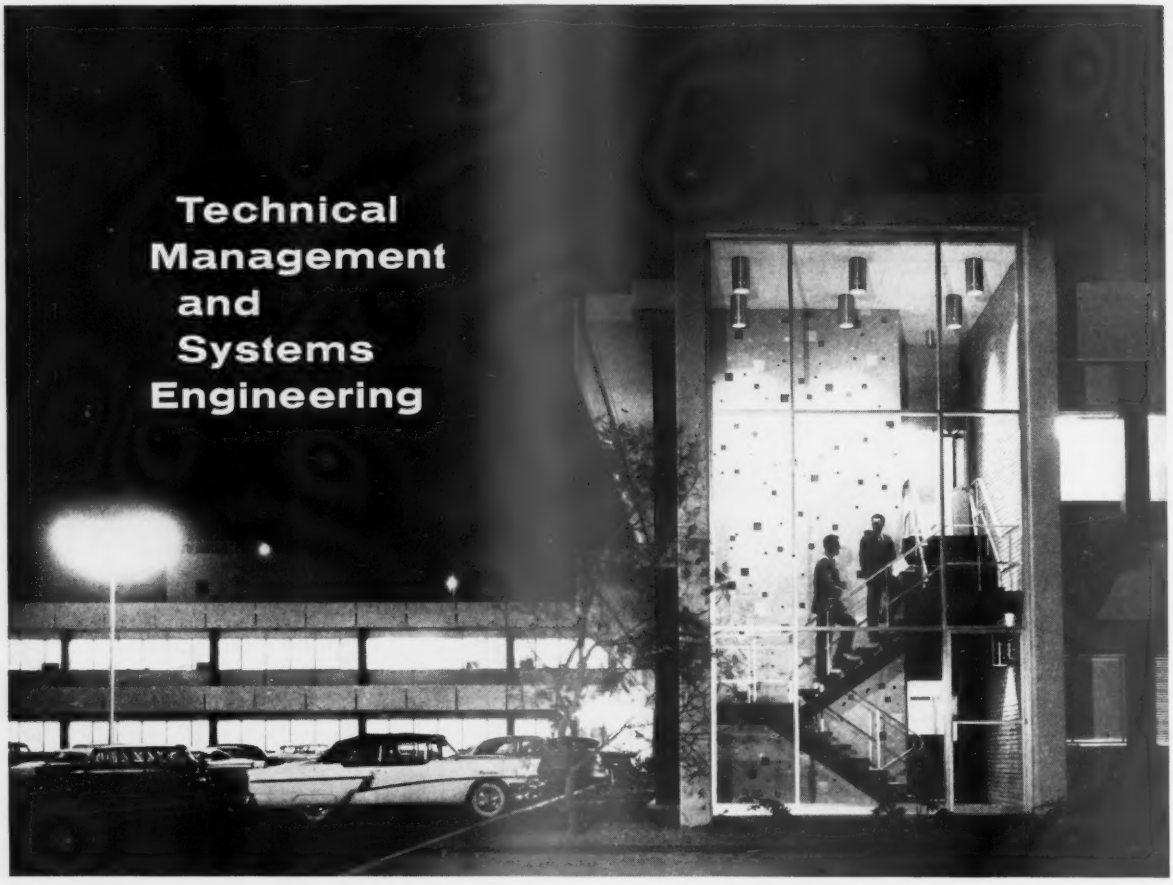

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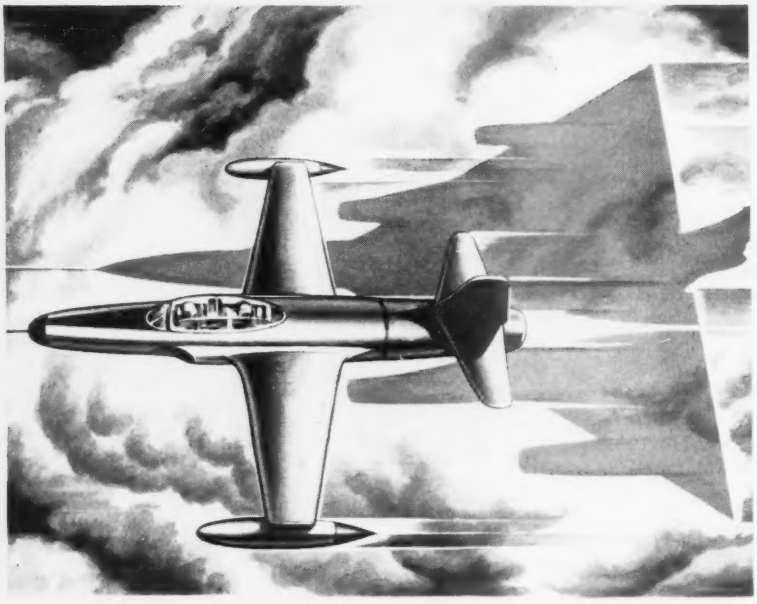

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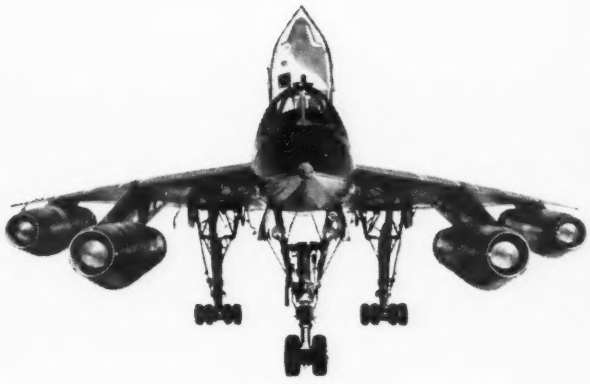

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Model Launching Techniques and Other Items Related to Range Firings. Joseph E. Long. (*Aero. Range Symposium, Proc.*, Jan., 1957.) *U.S. Army Bal. Res. Lab., Aberdeen, Rep. 1005, Pt. I*, Mar., 1957, pp. 273–297.

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Retractable Aircraft Landing & Taxi Light. Built to withstand 20g vibration and 15g shock; a worm drive on the lamp arm allows operation under high air loads. *Transco Products, Inc.*, 12210 W. Nebraska Ave., Los Angeles 25, Calif.

U-518914 Fuel Control Valve for Pilot Burners. Designed to meter fuel flow as a function of compressor and discharge pressure with a constant inlet fuel pressure and a scheduled fuel back pressure. *United Aircraft Products, Inc.*, 1116 Bolander Ave., Dayton, Ohio.

400-Cycle A.C. Motor with Double End Shaft. Features two-way ventilation for high self-cooling. *U.S. Electrical Motors Inc.*, Box 2058 Terminal Annex, Los Angeles 54, Calif.

Vertical Gyro Type WG-2. Claimed to provide accurate and reliable two-axis vertical reference data in the form of two synchro output signals. *The Waltham Watch Co.*, 221 Crescent St., Waltham 54, Mass.

2.5-Hp. 400-Cycle Aircraft Brake Motor. Weighs less than 10 lbs.; has a rated speed of 11,000 r.p.m. and a starting torque of 715 oz.in. *Western Gear Corp.*, P.O. Box 182, Lynwood, Calif.

"Connect-O-Matic" Hydraulic & Pneumatic Couplings. 8-page brochure shows complete line of hydraulic couplings. *E. B. Wiggins Oil Tool Co., Inc.*, 3424 E. Olympic Blvd., Los Angeles 23, Calif.

Small Metal Parts. Catalog No. 21 describes complete line of lugs, clips, terminals, wire forms, etc. *Zierick Mfg. Corp.*, Beechwood Ave., New Rochelle, N.Y.

ELECTRONIC & ELECTRICAL EQUIPMENT

Miniature Waveguide Switch. Provides rapid switching of signals from any one of three positions to either of the remaining two; will not change to another position upon failure of its power supply. *Airtron, Inc.*, Dept. C, Linden, N.J.

Microminiature Circuit Balancing Potentiometer. Model 220 measures 3/16 by 5/16 by 1 in.; designed for a maximum operating temperature of 175°C. *Bourns Laboratories, Inc.*, 6135 Magnolia Ave., Riverside, Calif.

Model 160 Sweep-Frequency VSWR Measuring System. Employing a backward-wave oscillator, this new unit can sweep all or any portion of its range at rates of 0.02, 0.1, 1.0, and 3.0 cps. *California Technical Industries*, 1402 Old County Rd., Belmont, Calif.

Aircraft Buffet Unit Connectors. 8-page bulletin BU2 shows 13 types with from two to six contacts. *Cannon Electric Co.*, 3208 Humboldt St., Los Angeles 31, Calif.

K & RK Electrical Connectors. 64-page catalog No. K6. *Cannon Electric Co.*, 3208 Humboldt St., Los Angeles 31, Calif.

Communications & Electronic Systems. 100-page 1957 General Catalog describes company's complete line of products. *Collins Radio Co.*, 315 2nd Ave., S.E., Cedar Rapids, Iowa.

Miniature High-Altitude Connectors. A staggered construction gives long creepage path between pins despite small connector dimensions. *Consolidated Electrodynamics Corp.*, 740 Salem, Glendale, Calif.

Air-Borne D.C. Power Supply. Provides three highly regulated simultaneous outputs. *Davenport Mfg. Co.*, Dept. ARN, 1713 N. Ashland Ave., Chicago 22, Ill.

Miniature Electrical Connectors. 24-page catalog describes miniature hermetic, quick disconnect, push-pull, rack and panel, and edgelite panel connectors. *The Deutsch Co.*, 7000 Avalon Blvd., Los Angeles 3, Calif.

Miniature Magnetic Pickup. This sensitive transducer translates the movement of ferrous objects into a variable and measurable A.C. voltage. *Electro Products Laboratories, Inc.*, 4501 N. Ravenswood Ave., Chicago 40, Ill.

High-Temperature Thermosetting Casting Resin. Suitable for encapsulating assemblies to withstand high operating and ambient temperatures. *Electronic Plastics Corp.*, 675 Barbey St., Brooklyn 7, N.Y.

"Glennite" Microwave Absorbing Materials. Designed for application where radiating microwave equipment has to be aligned or tested in restricted spaces. *Gulton Industries, Inc.*, 212 Durham Ave., Metuchen, N.J.

Wafer, Rod, & Bead Thermistors. 10-page bulletin lists typical applications and circuitry. *Gulton Industries, Inc.*, Thermistor Div., 212 Durham Ave., Metuchen, N.J.

"Fused-Film Wire." A new method of coating magnet, lead, and hook-up wire with a thin film of Teflon insulation 0.002 of an inch thick; process gives high thermal and dielectric strength to small motor wire. *Inso Products, Ltd.*, Sub. of Adam Consolidated Industries, Union, N.J.

Microminiature Coaxial Cables & Connectors. New 32-page 1957 catalog describing company's complete line is now available. *Microdot Inc.*, 220 Pasadena Ave., South Pasadena, Calif.

Cooling Equipment for Electronic Applications. 8-page brochure "What We Make" shows the scope of Rotron's products and engineering services. *Rotron Mfg. Co.*, Schoonmaker Lane, Woodstock, N.Y.

Miniaturized "Klixon" Aircraft Circuit Breakers. Weigh less than $1\frac{1}{2}$ oz.; feature only three moving parts—actuator, slide, and thermal disc. *Spencer Thermostat Div.*, Metals & Controls Corp., Attleboro, Mass.

Tubeless Magnetic Automatic Voltage Regulator. For high-frequency duty; designed for 400-cycle, single-phase applications where requirements demand small, lightweight equipment. *The Superior Electric Co.*, Dept. TMH, 83 Laurel St., Bristol, Conn.

Lever-Actuator Mechanism for Subminiature Switches. Provides extremely light operate-force. *Unimax Switch Div. of The W. L. Maxson Corp.*, Ives Rd., Wallingford, Conn.

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Miniaturized External Anode Tube. Weighs 0.702 oz.; is 2 in. long, 7/8 in. wide, and has a shock rating of 300*g*. *United Electronics Co.*, 42 Spring St., Newark, N.J.

Molded Lightweight Aircraft Current Transformer. Has a 250/2-amp. current ratio and operates on 115-volt, three-phase, four-wire, 400-cycle systems. *Westinghouse Electric Corp.*, P.O. Box 2099, Pittsburgh 30, Pa.

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"Certrifil" Filter-Centrifuge Unit. For cleansing of hydraulic fluids and systems; practically 100 per cent removal of all metallic and nonmetallic contaminants is claimed. *Permanent Filter Corp.*, 1800 W. Washington Blvd., Los Angeles 7, Calif.

RESEARCH & TEST EQUIPMENT

Pitot-Static Tester. Data sheet tells how this unit makes possible the flight line testing of pitot-static systems in aircraft. *Aircraft Products Co.*, Tactair Valve Div., 300 Church Rd., Bridgeport, Pa.

High Rate Tensile & Compressive Tester. Model 625 provides a completely calibrated stress-strain record of the deformation of a specimen at rates to 6,000 in. per min. *Allegany Instrument Co.*, 1091 Wills Mountain, Cumberland, Md.

Thrust Assembly for Off-Axial Measurements. For measurement of thrust components in rocket and jet engines. *Allegany Instrument Co.*, 1091 Wills Mountain, Cumberland, Md.

Automatic-Calibrating Bridge Balance Unit. Model 24-202 is of special value when recording dithering-type information and provides calibration steps that are truly square wave for clearer interpretation. *B & F Instruments, Inc.*, 4732 N. Broad St., Philadelphia 41, Pa.

S-100 Series Temperature Probes. Designed for precise measurements at very low temperatures. *Gulton Industries*, 212 Durham Ave., Metuchen, N.J.

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Model 561 Recording Oscillograph. Can survive shock accelerations above 1,500*g*. *Midwestern Instruments*, 41st & Sheridan Rd., Tulsa, Okla.

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PAR-1 Oscillographic Recording System. Designed to provide an extremely accurate method of obtaining an oscillographic presentation of data which has been recorded on magnetic tape. *Midwestern Instruments*, 41st & Sheridan Rd., Tulsa, Okla.

Wide-Band Magnetic Tape System. Records closed-circuit television signals on magnetic tape in an air-borne installation. *Minnesota Mining & Mfg. Co.*, Mincom Div., 2035 S. Barrington Ave., Los Angeles 25, Calif.

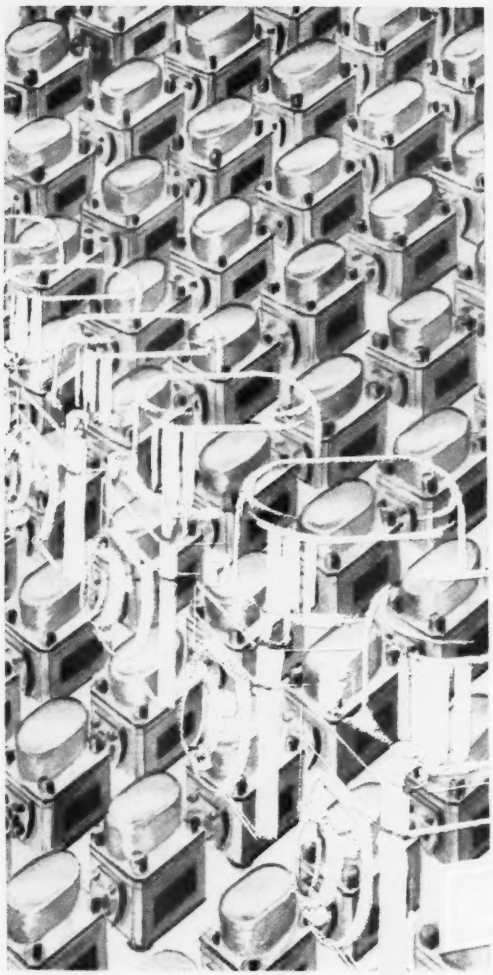
Microwave & UHF Electronic Test Equipment. 48-page catalog covers Narda's complete line of wave-guide test equipment, radar test equipment, bolometers and thermistors, and coaxial and UHF equipment. *The Narda Corp.*, 160 Herricks Rd., Mineola, N.Y.

"Plasmatron" High-Temperature Heat Source for Laboratory Research. Capable of producing and maintaining a continuous, controllable temperature up to 15,000°K. (26,540°F.). *Plasmatron*, 18400 S. Main St., Santa Ana, Calif.

"RdF Strapon" Resistance Thermometer. For surface temperature measurement; a reusable and flexible instrument applicable in presence of most substances that normally render temperature transducers ineffective. *Arthur C. Ruge Associates, Inc.*, Cambridge, Mass.

Magnetic Tape Recorder/Reproducer. Capable of recording continuously, unattended without tape change, for 24 full hours. *The SoundScriber Corp.*, New Haven, Conn.

SPS Titanium Temperature Report. This report contains data on tensile, shear, and fatigue strength tests at temperatures ranging up to 600°F. *Standard Pressed Steel Co.*, Box 869, Jenkintown, Pa.



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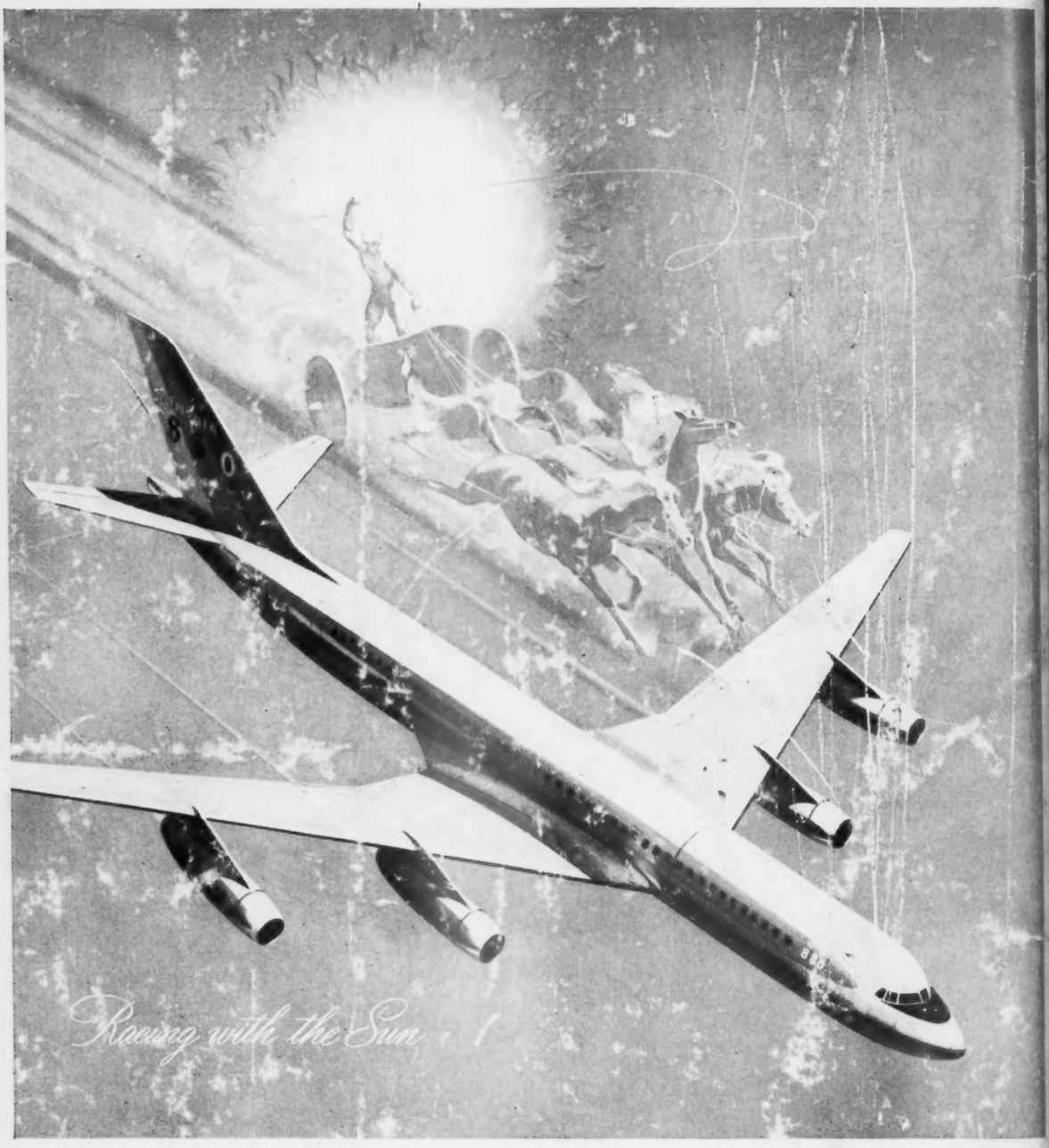

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